Instruments

THE MAGAZINE OF
MEASUREMENT · ANALYSIS · COMPUTING
INSPECTION · TESTING · CONTROL

Including the

JOURNAL OF THE INSTRUMENT SOCIETY OF AMERICA

(page 733)

and the

JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION

(page 745)

In this issue . . .

Electronic Control
Soaking Pit Instrumentation
Open-hearth Pyrometry
Process Control
Miniature Pressure Cells
Pneumatic Refractometer
Frequency Response
144 New Instruments
186 New Bulletins

Douglas Aircraft Co. uses Midwestern "Model-544" to determine welding variables. For story see page 630. (Courtesy Midwestern Geophysical Laboratory.)

Vol. 26 No. 5
MAY • 1953

WHEN IT'S LIQUID LEVEL CONTROL

...it's FISHER®

FISHER®

LEVEL-TROL

...the Accepted Standard

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Write for Bulletin F-3

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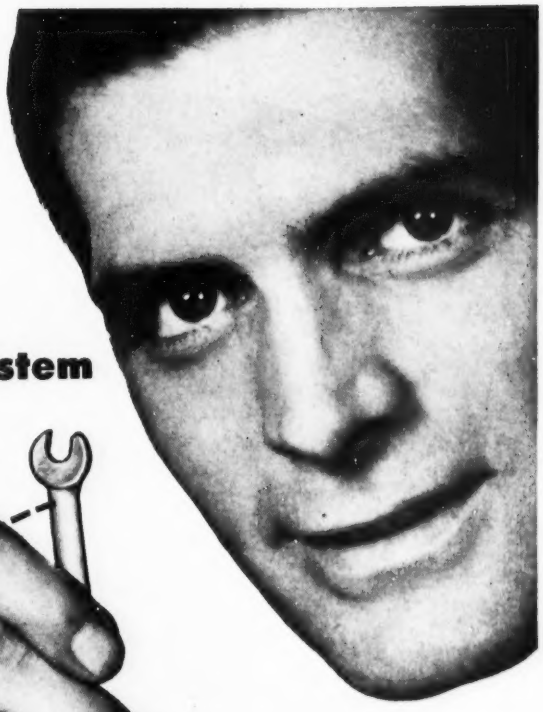
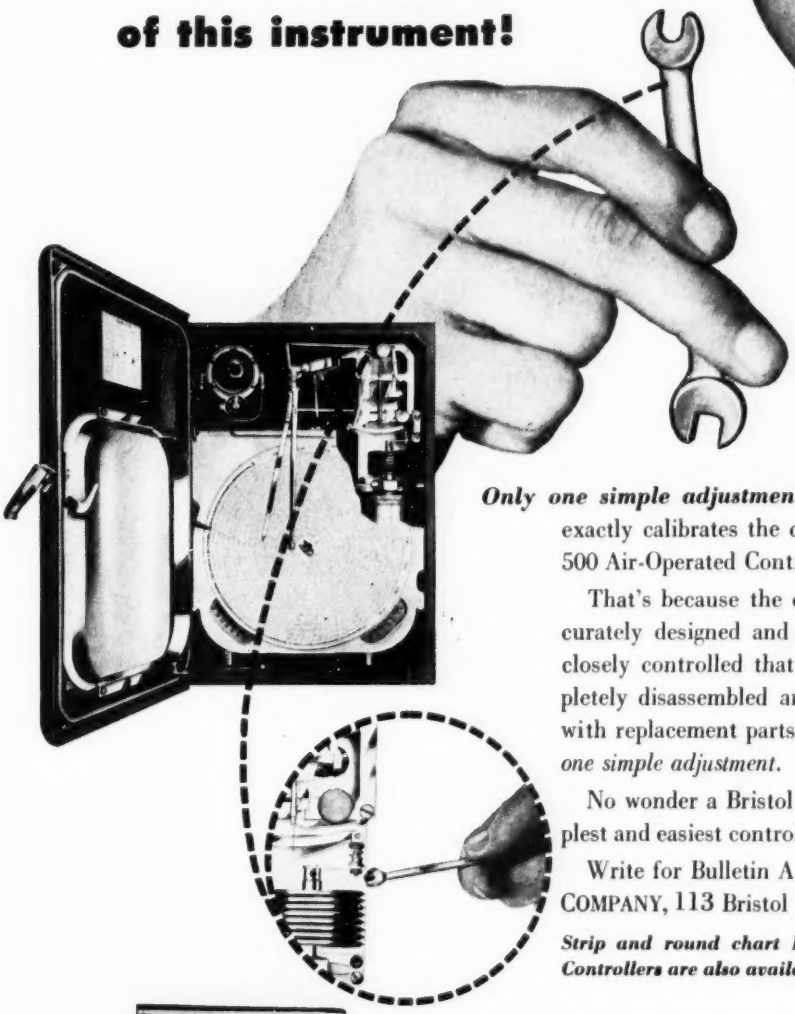
For further information circle 1 on inquiry card.

Here's the only tool you need to exactly calibrate the control system of this instrument!





Only one simple adjustment with a standard 1/4 in. wrench exactly calibrates the control system in a Bristol Series 500 Air-Operated Control System.

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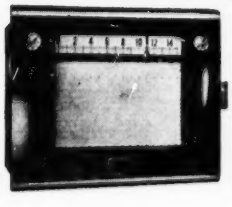

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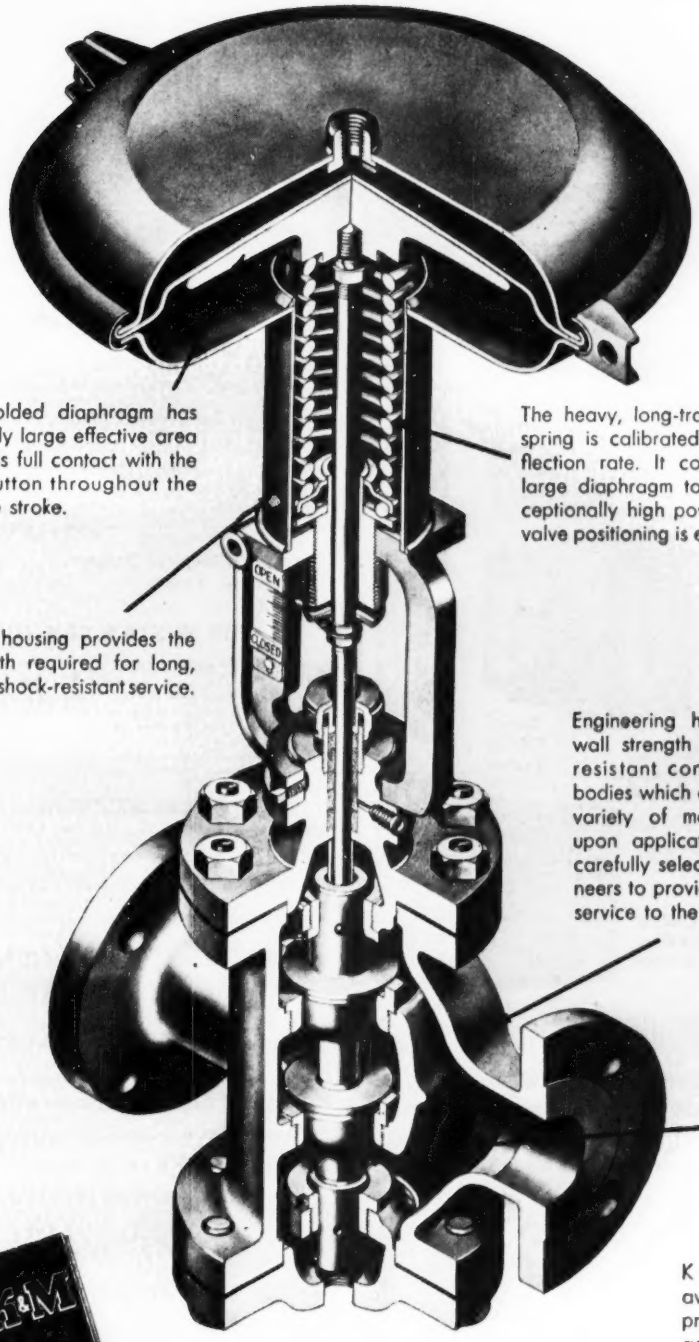
For further information circle 2 on inquiry card.

Stamina

Rugged construction in every detail enables the K&M Diaphragm Control Valve to remain in perfect control under the most punishing conditions. The entire diaphragm motor assembly is of ALL STEEL construction. Controlled positive positioning results from the balanced inter-action of the large diaphragm and the heavy, long-travel spring. Engineering has provided extra wall strength and high-pressure-resistant contour to the valve body.

[redacted]

For further information circle **3** on inquiry card.



The K & M molded diaphragm has an exceptionally large effective area and it maintains full contact with the diaphragm button throughout the complete valve stroke.

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K & M inner valves are available in wide variety to provide desired flow characteristics for all process applications.

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K&M

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Valve Makers Since 1879
Middletown, New York

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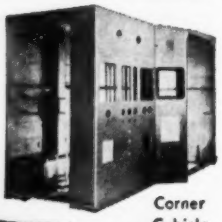

Five Section Cubicle Control Board and Lighting Canopy

Corner Cubicle Section

Refinery Cubicle with Mimic Flow Diagram in Color

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Experienced designing and quality fabrication assure the efficiency of any indicating, recording, or control installation. Whether you are planning new construction, modernizing existing installations or adding to present equipment, FALSTROM offers long years of experience and the most modern facilities for fabricating to your specifications or recommending standard designs. In any case, by specifying FALSTROM you specify the highest possible quality metal working techniques known to the industry. Estimates on your needs will be supplied promptly—call or write FALSTROM to arrange a consultation.

WRITE FOR BULLETIN #125

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92 Falstrom Court, Passaic, New Jersey
DESIGNERS, ENGINEERS AND BUILDERS OF CUSTOM METAL PRODUCTS FOR INDUSTRY

For further information circle 4 on inquiry card.

Instruments
THE MAGAZINE OF MEASUREMENT INSPECTION · TESTING · CONTROL

Vol. 26 May 1953 No. 5

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By Ben D. Stanton

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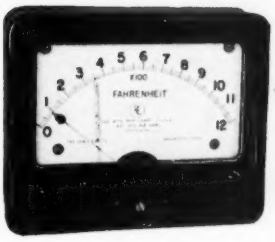
LEWIS

AUTOMOTIVE AND INDUSTRIAL TEMPERATURE MEASURING EQUIPMENT

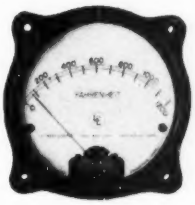
Sturdy Dependable Indicators —Suitable For Use In Moving Vehicles or For Permanent Installation

This instrument has been used extensively by the leading motor-car manufacturers for road testing on the "Proving Grounds" — where performance counts. Housed in a rectangular bakelite case, this reliable, fully compensated pyrometer is furnished with 6 in. hand drawn scales for greater accuracy. The Model 58PY is available for use with all standard thermocouple materials, in many ranges to suit the most exacting application.



MODEL 58PY

Manufactured with the same type of movement as our aircraft pyrometers, the Model 23B pyrometer is well suited for use in moving vehicles and has been successfully used in many marine diesel installations for measuring exhaust temperatures. It is housed in a 4 in. round bakelite case that is flanged for panel mounting, and is available in several ranges for use with various thermocouple materials.



MODEL 23B

The Model 20B series of indicators are patterned after our standard aircraft instruments and are supplied with 3" round steel cases suitable for panel installation. These compact, sturdy indicators have 2⅛ in. scales, are fully cold-end compensated and are available in many ranges for use with various thermocouple materials.

MODEL 20B

The Model 62RT4F resistance thermometer is a sturdy easy-to-read instrument with a 6 in. hand drawn scale. It is suitable for use in moving vehicles and is excellent for flight-test work. It is operated by an ordinary dry cell and is calibrated to standard "AN" bulb curves for various ranges in fahrenheit or centigrade.

MODEL 62RT4

THERMOCOUPLES for use with the above indicators are available in many styles for special applications. We have developed a complete line of aircraft, industrial and automotive thermocouples and would be pleased to offer our recommendation for your application.

THERMOCOUPLE LEAD WIRE for connecting thermocouples to the indicators is manufactured in iron-constantan, copper-constantan or chromel-alumel material with standard and special insulation. Use Lewis lead-wire with Lewis instruments and thermocouples for best results.

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...ARE PROVIDING SNAP-ACTION-POWER IN REMOTE CONTROLLED APPLICATIONS!

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Instruments

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COVER STORY

The Resistance Welding Department at the Tulsa Division of the Douglas Aircraft Co. uses the Midwestern "Model 544" Oscillograph to determine the magnitude of welding variables and accuracy of calibration. It is used also to test the performance of such component parts of a welding unit as electro-valves, relays, etc. Current and force signals are relayed to the oscillograph by means of a copper-bar shunt and a strain-gage bending beam. Analysis of time relation, duration and magnitude of current, and force traces verify the accuracy and performance of the welding machine.

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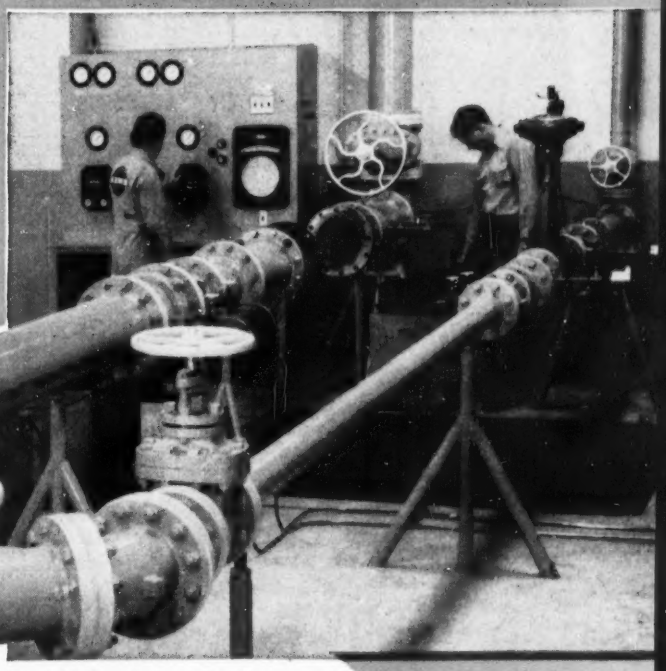
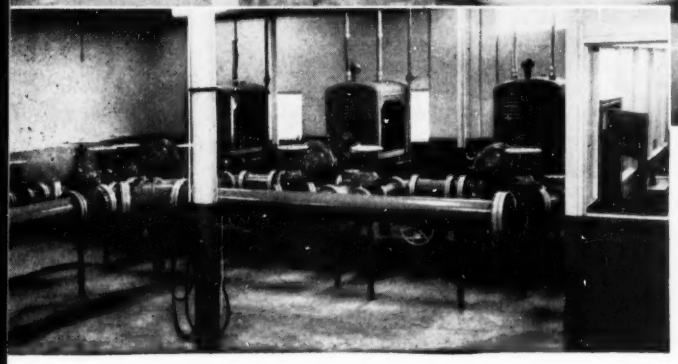
Testing the performance on which BS&B reputation has been built;

Pre-Proving CLIMAX CONTROLS to Insure On-The-Job Efficiency

Experimentation is the first step in final development. This interesting corner of the new Climax Hydraulics and Experimental Laboratory at BS&B's Tulsa plant is under the charge of experienced development engineers. New Climax designs and improvements start here.



The finished control on the "torture rack." Meter runs flow test the valves up through 10". Strain gauge equipment analyzes forces and stress under performance. Control panel in background regulates engines driving the pumps and registers flow data for calculation.



Pump manifolding for the 3 engine-driven pumps which will deliver up to 4500 gallons per minute at a 100 lb. discharge for high volume tests. Pumps can also be manifolded for series operation, in which case 300 lbs. of water at 1500 gallons per minute can be delivered.

There's no question about a Climax Control giving the satisfactory service for which it is designed. That performance is tested and proven before the control goes into the field . . . checked for minimum and maximum capacity. Flow, flow effects, valve characteristics and strain results are all evaluated by experienced engineers. Through the new BS&B Climax Control Hydraulics laboratory come a continuing series of answers to the more efficient, safe and profitable application of automatic controls. One test suggests another, one application is adapted to a similar problem. The net result: Through research, better engineering, and accurate pre-testing, comes a more efficient Climax Control.

New Climax Controls Hydraulic and Experimental Laboratory

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Climax Controls Division, Dept. 4-V5
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CLIMAX BS&B CONTROLS OUR 60TH YEAR

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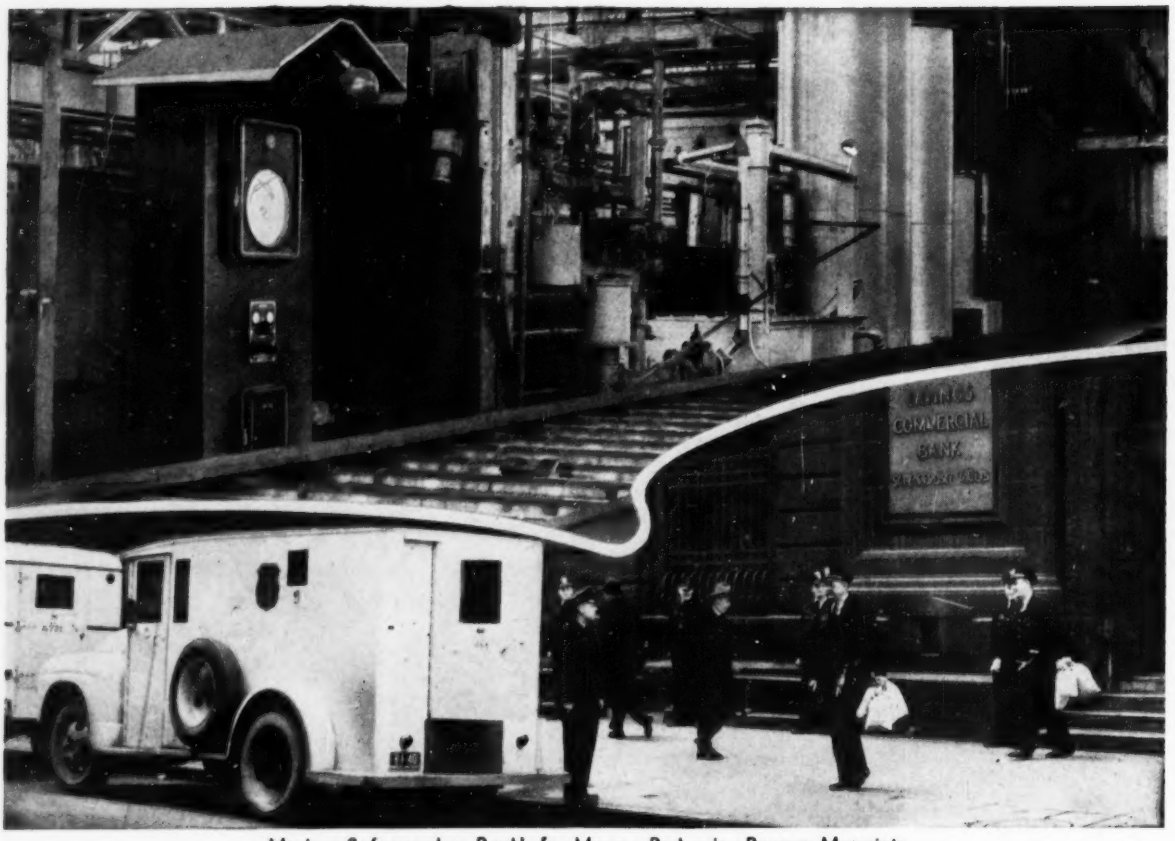

Modern Safeguards—Brink's for Money, Bailey for Process Materials

Are Your Process Materials Guarded As Well?

HERE'S HOW TO PREVENT SPOILAGE AND WASTE . . .

TO avoid waste of valuable process materials and finished products, process rates and conditions must be accurately measured and controlled. That's were Bailey Meters, Analyzers and Controllers can help you to improve the efficiency of your plant.

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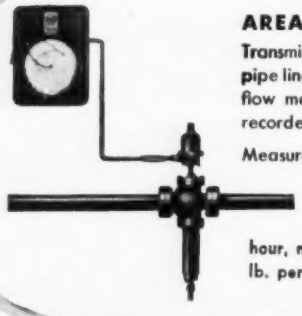
When you call Bailey Meter Company, you get the help of years of experience as well as recommendations from a wide selection of measuring and controlling devices.

Your local Bailey Engineer is as near as your telephone. He has the experience and the equipment necessary to set up an effective guard for your process materials.



AREA TYPE FLOW METER

Transmitter goes into 1, 2 or 4 inch pipe line like a valve and transmits flow measurements electrically to recorder in remote location.

Measures oil and other clear liquids under static pressures up to 600 psi. Minimum range 0 to 1200 lb. per hour, maximum range 0 to 96,000 lb. per hour.

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Process Controls
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GAS ANALYSIS · RATIO

For further information circle 8 on inquiry card.

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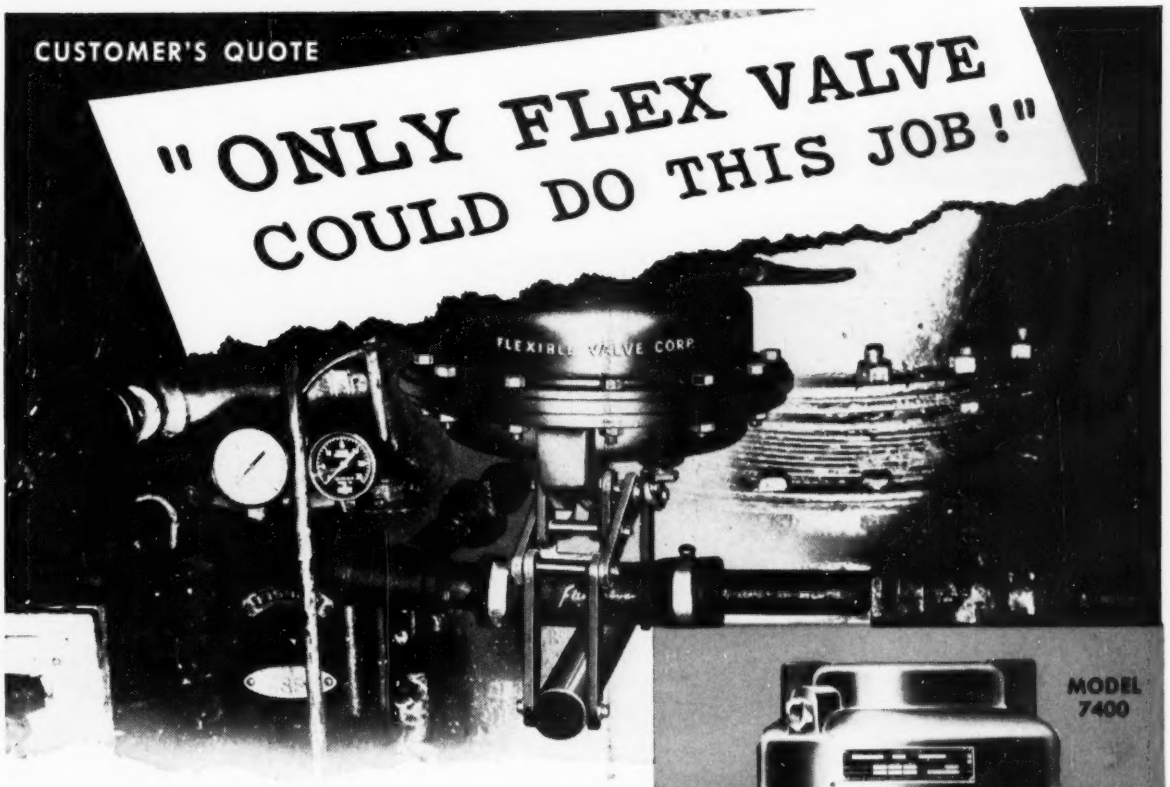
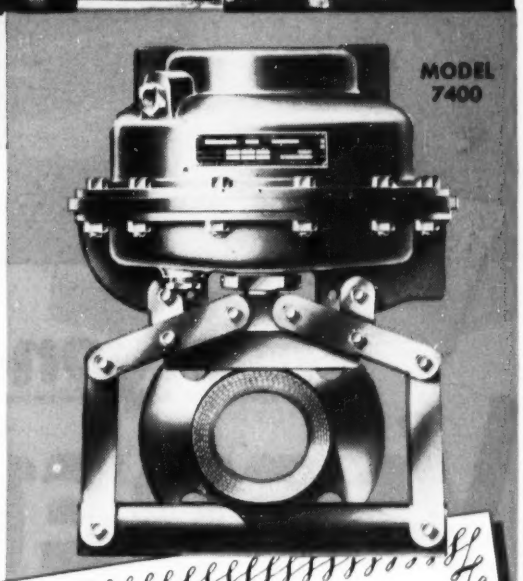
"ONLY FLEX VALVE COULD DO THIS JOB!"





This diaphragm motor-operated Farris Flex Valve is handling a hard-to-convey, semi-solid slurry in a leading chemical processing plant. Before it was installed, other types of valves clogged after as little as a few hours' service. *Yet Flex Valve has performed perfectly for more than 3 years, in a 24-hour, 7-day-week operation.* Many other Flex Valve installations have been giving trouble-free, continuous service for 15 years or more. If you have a problem in controlling flow of any hard-to-handle fluid, send for Catalog No. FL 382 **C.**

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- Excellent control characteristics in first ⅓ of travel.
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- Valve body available in pure gum rubber, neoprene, butyl, buna-n, buna-s, food stock and special compounds.

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YOUR MONEY BACK
if Flex Valve plugs

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For further information circle 9 on inquiry card.

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Added Evidence that——

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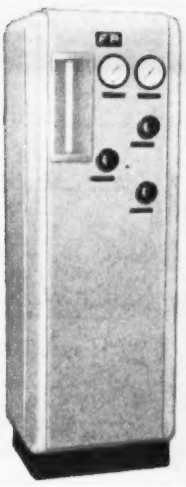
For further information circle 10 on inquiry card.

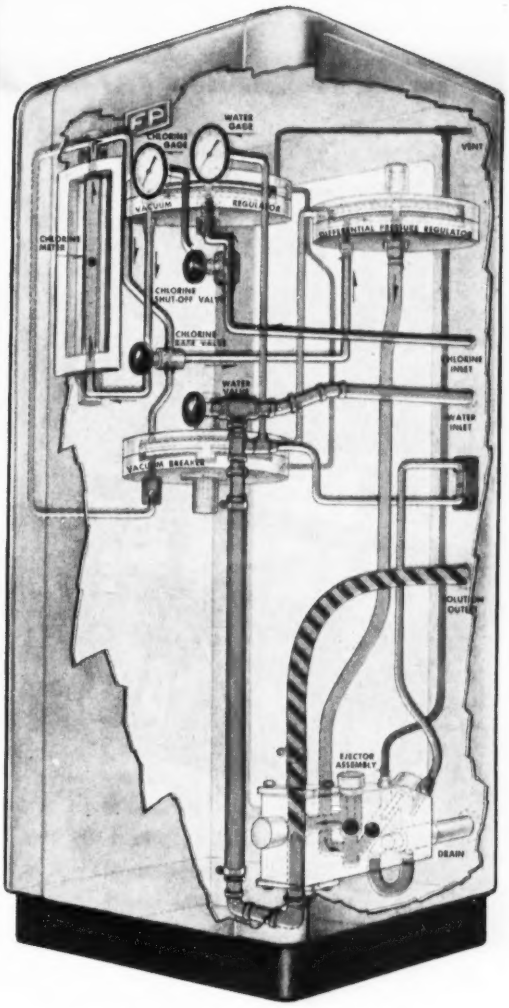
new

RATOCHLOR 1050

CHLORINE DISPENSER

every inch corrosion resistant





From cabinet to valves, every part of the new Ratochlor unit is as corrosion resistant as modern science and technology can make it, the result of years of field and laboratory tests in the handling of both dry and moist chlorine gas.

The complete outer cabinet is made of a new polymer-impregnated fibre glass material, whose attractive grey color permeates the entire material.

Control operations inside the cabinet center around a corrosion resistant Flowrator meter, which provides direct, accurate, wide range of chlorine flow rate. New corrosion resistant materials recently developed in the research laboratories make it possible to incorporate the safety and simplicity of the diaphragm-regulator principle in the 1050 Ratochlor. Water seals are eliminated.

The design of the new 1050 Ratochlor provides the fullest control of chlorine solutions, the most advanced materials and methods to combat corrosion. It can be readily adapted for program control, proportioning and remote control. A complete and comprehensive discussion of the new 1050 Ratochlor and its operation is available in booklet form. Write for Catalog 61 now.

CHECK THESE ADVANTAGES

- SAFETY
- complete corrosion resistance — using Uscolite, Teflon Kel-F, Tantalum and other materials
- direct, visible flow measurement
- maximum water economy
- dependability — minimum working parts
- solution feed standard (gas feed available)
- constant vacuum
- manual rate adjustment

FP

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1350 County Line Road
Hatboro, Pennsylvania, U.S.A.

FLOWRATOR

FP 2110

For further information circle 11 on inquiry card.

We haven't cut corners on *QUALITY CONTROL* to speed deliveries for–

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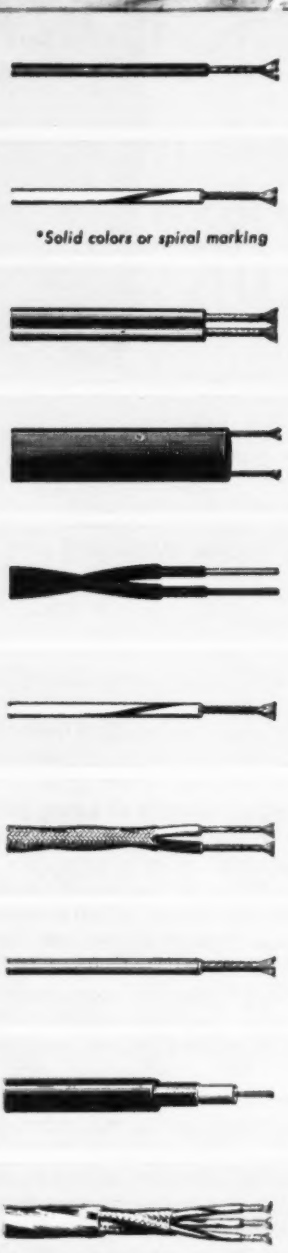
WIRES & CABLES

Extra shifts, not speed-ups are the way Chester catches up on production to meet your delivery dates. Chester Wires and Cables are never rushed through... every foot is quality controlled according to the highest standards known to the industry. This is the reason Chester Wires and Cables are of uniform quality, always dependable, whether you use a foot or a spool. For an extra measure of reliability, specify Chester, for your next electrical or electronic requirements.



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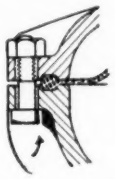
For further information circle 12 on inquiry card.

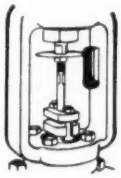
Single wrench maintenance

check these time and money-saving maintenance features

1 **CAST FLATS** make bolts easy to remove on superstructure. Heads can't turn . . . only one wrench needed.

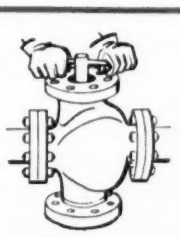


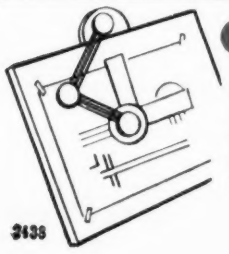
2 **WIDE YOKE**—plenty of room for big hands to work with that one wrench.



3 **FLATS** on valve stem use same adjustable wrench—does not score stem.

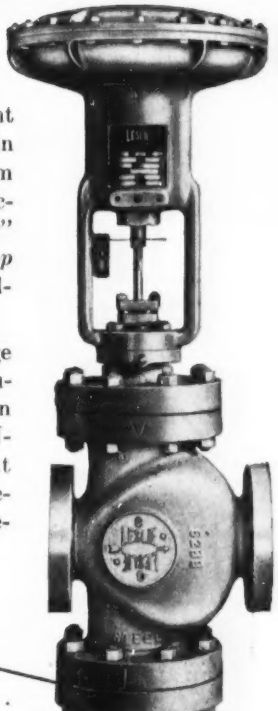
4 **SEAT RINGS** can be renewed without taking the valve body from the line. No vises, no lathes. Standard Leslie practice for 27 years, not a theory, a proven fact.





5 **INTERCHANGEABLE** parts keep inventory small, reduce down-time. Top grade materials and engineering means less maintenance.

3638



There are a host of important features found as *standard* in Leslie Double-Seated Diaphragm Control Valves usually manufactured only in "made-to-order" units — features that mean *top* performance and *extra*-dependable service.

But here's one more advantage that makes Leslie the most popular valve with maintenance men —SINGLE WRENCH MAINTENANCE. They find that maintaining the Leslie Double-Seated Control Valve is a one-tool job.

WHEN SPECIFYING . . .

for pressure, temperature and level controls, a quick check can prevent ordering a *special* that Leslie makes as *standard*. A call to your Leslie Engineer, before you specify, is free insurance. He's listed under "Valves" or "Regulators" in the classified telephone directories in principal cities.

Send for free Bulletin 5305

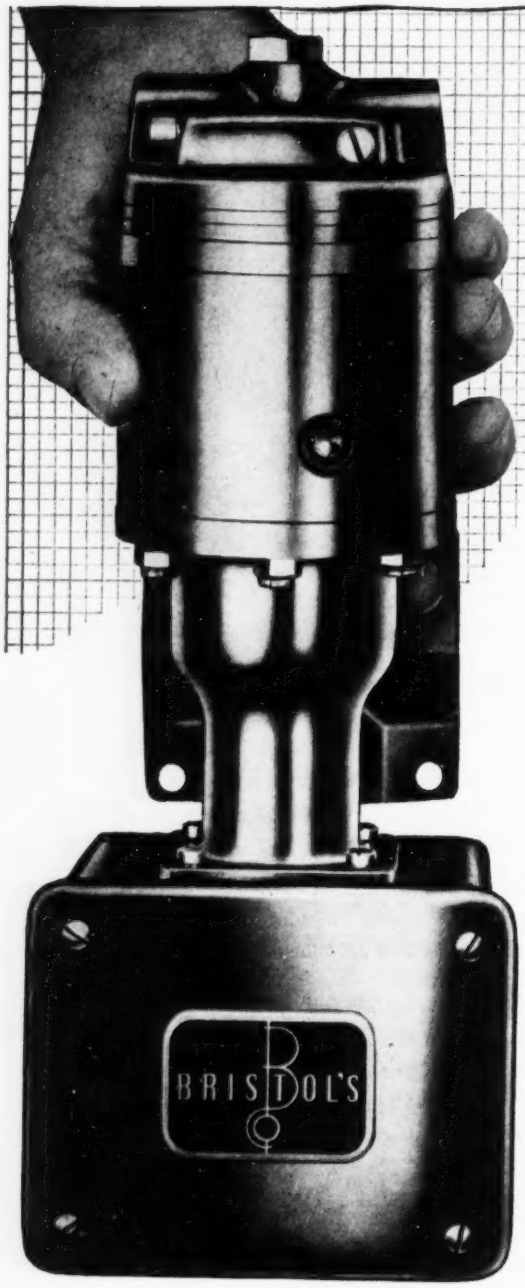
12 new pages of valuable data on double-seated diaphragm control valves.

TRADE LESLIE MARK

LESLIE CO., 299 **GRANT AVE., LYNDHURST, N. J.**

For further information circle 13 on inquiry card.

WHAT'S NEW AT BRISTOL . . . . . WHAT'S NEW AT BRISTOL



New Bristol Series 650 PNEUMATIC TRANSMITTERS

for use with

BRISTOL MINIATURE RECORDERS, INDICATORS, AND CONTROLLERS

. . . give you these new advantages

● **THEY USE BRISTOL WORLD-FAMOUS MEASURING ELEMENTS—the measuring elements with wide-angle travel for positive action.** These are the same standard Bristol measuring elements that are used in Bristol Recording and Controlling Instruments. They are the result of over 60 years of experience in instrument making and application in practically every industry. Bristol measuring elements are recognized the world over for their accuracy, simplicity, and reliability. There are no better measuring elements made than Bristol measuring elements.

● **TRANSMITTING UNITS PROVEN TO BE ABSOLUTELY RELIABLE AND TROUBLE-FREE. They are very sensitive** to extremely small changes in the measured quantity, as little as 0.03% of range, including reversal. Superior control results from the use of a booster valve with output capacity of 3.0 scfm.

● **SIMPLE TRANSMITTING MECHANISM—frictionless operation**—only one pivot and no flexures—will operate in any position—is weatherproof and can be installed in any location, pipe-saddle or surface mounting.

● **AVAILABLE IN A WIDE SELECTION OF RANGES:** Pressure (0 to 5" water to 0-10,000 psi), vacuum (0 to 5" water to full vacuum), temperature (−100° F. to 1000° F.), liquid level (0 to 5" water and up), flow (mercury manometer, bell type, and Barton meter bodies), and differential pressure (0 to 2.0" water to 0-500" water). Suppressed ranges available. Over-range is standard, up to 500% for some ranges. Write for free bulletin No. A105. The Bristol Company, 113 Bristol Rd., Waterbury 20, Connecticut. **6.3.8.**

LOOK FOR OUTSTANDING NEW DEVELOPMENTS FROM BRISTOL.

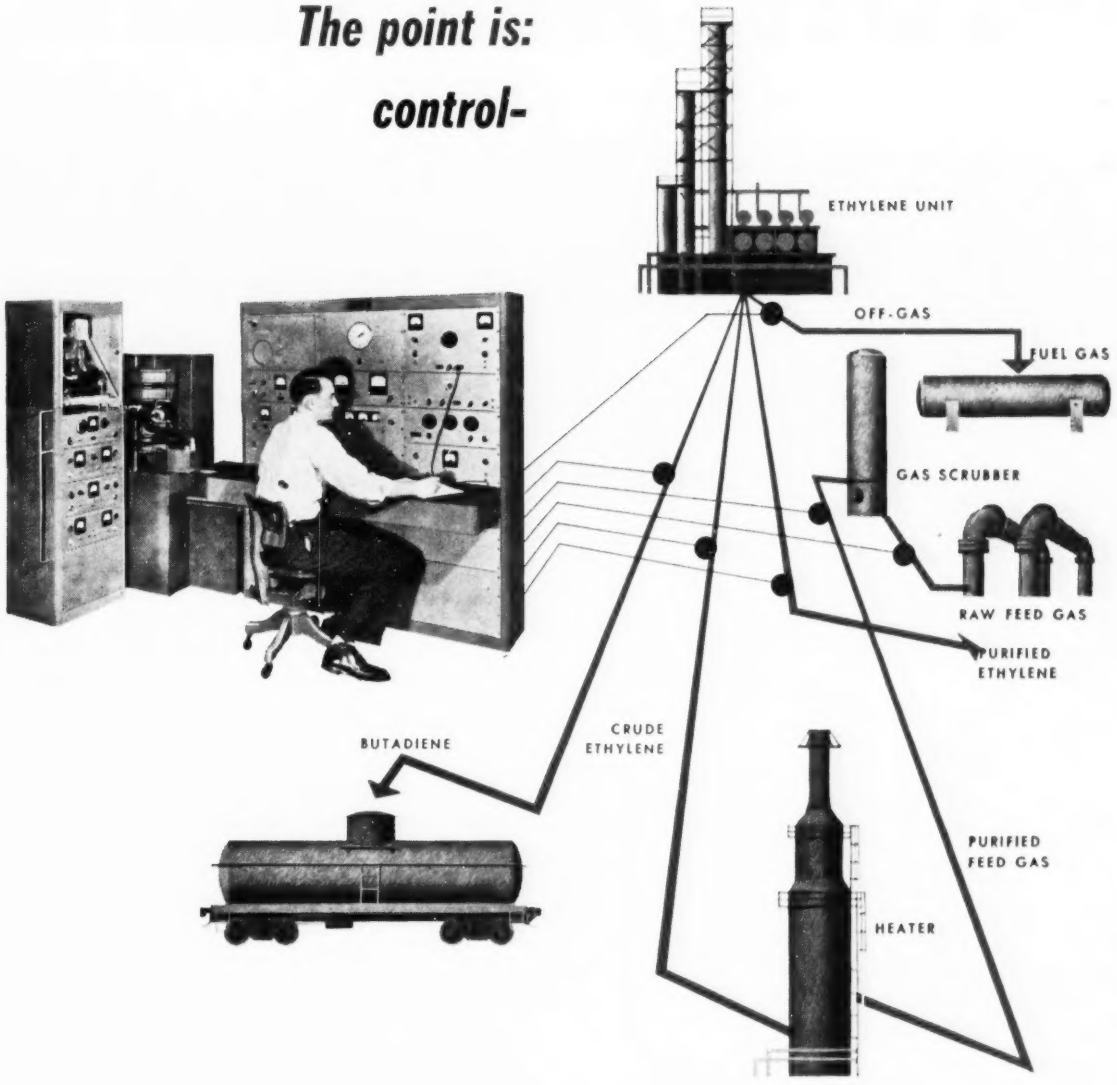
BRISTOL

THE DEPENDABLE GUIDEPOST OF INDUSTRY

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For further information circle 14 on inquiry card.

The point is: control-



IN THE huge Texas plant of Jefferson Chemical Company, Inc., at Port Neches, Texas, approximately 50,000 complex control analyses of hydrocarbon mixtures have been made on a single Consolidated Analytical Mass Spectrometer since 1947. These figures indicate the speed, accuracy, and trouble-free service that can be built into a sensitive analytical instrument. For year-in, year-out operation this versatile control instrument offers decided advantages: the cost-per-analysis is only a fraction of the cost by any other method and the results are available in permanent graphic form in a fraction of time otherwise required. One operator and a Consolidated Mass Spectrometer will accomplish complete control over the most complicated chemical processes—in minutes.

Consolidated Engineering

CORPORATION

300 North Sierra Madre Villa, Pasadena 15, California

Sales and Service through **CEC INSTRUMENTS, INC.,** *a subsidiary with offices in: Pasadena, Philadelphia, New York, Chicago, Dallas*

analytical instruments for science and industry

Mass Spectrometer

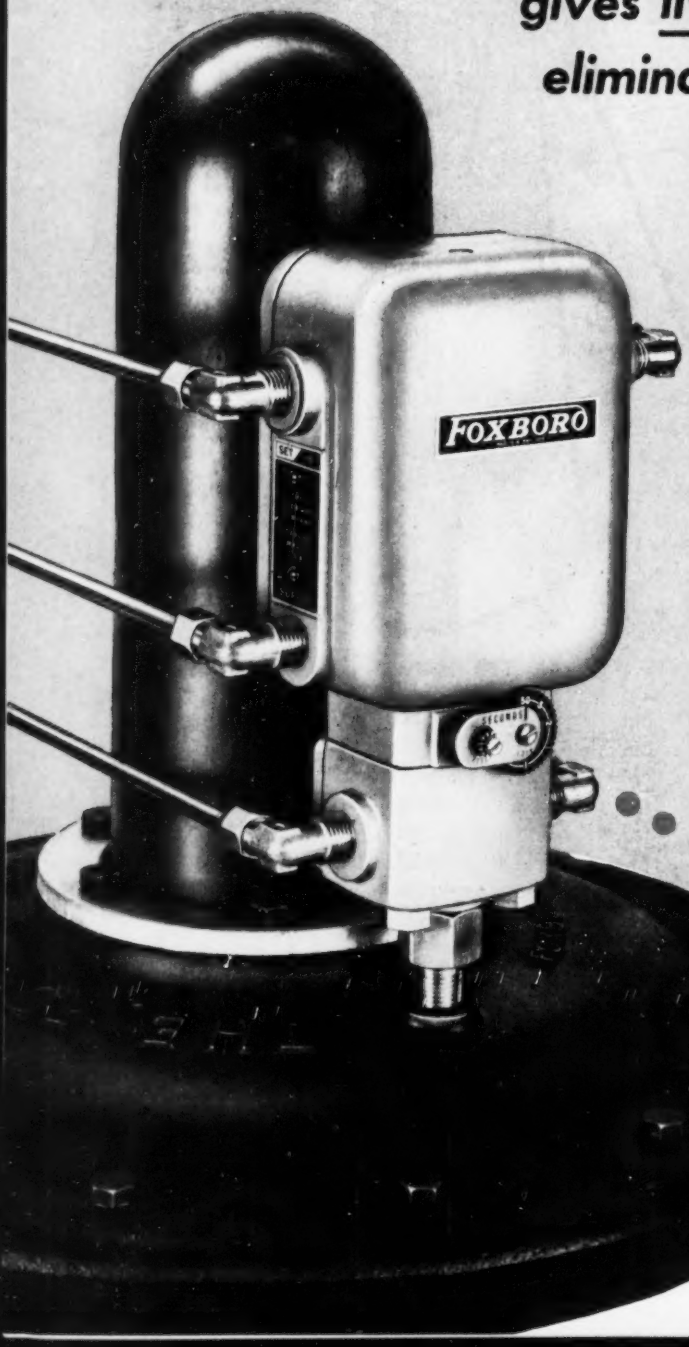
The Consolidated Analytical Mass Spectrometer shown above is used extensively by leading refineries throughout the world for analytical research as well as process control. For complete information on this instrument, write for Bulletin CEC 1800-X6

For further information circle 15 on inquiry card.

NOW CONTROL FLOW

M/59 Consotrol Controller

gives live-balance sensitivity, eliminates transmission lag.



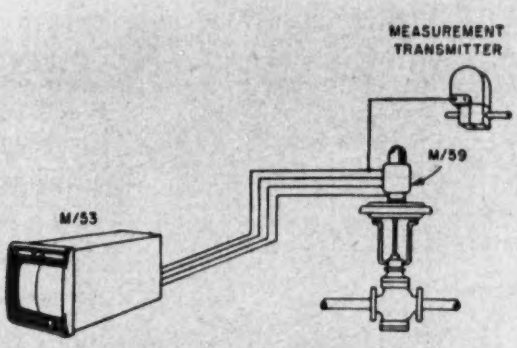
Designed specifically for *dynamic* control of flow, the M/59 Consotrol Controller takes full advantage of the speed and sensitivity of the Foxboro d/p Cell (flow transmitter). It is the direct result of Foxboro basic research into today's flow control problems.

This revolutionary flow controller combines inherently dynamic action with unique simplicity of design. Mounts directly on valve — no transmission line, no lag!

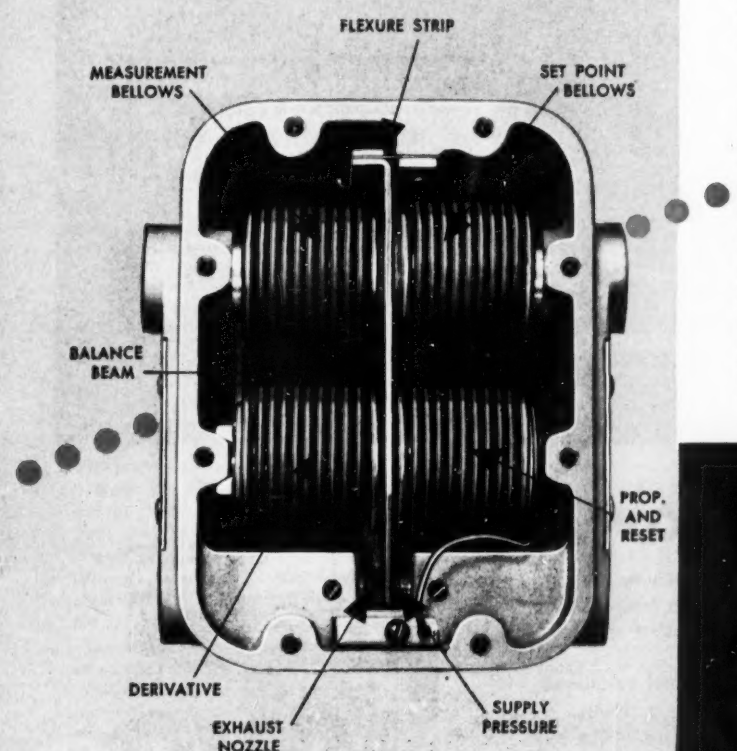
Write for Bulletin 470 which fully describes this outstanding development in flow instrumentation. The Foxboro Company, 465 Neponset Ave., Foxboro, Mass., U.S.A.

For further information circle 16 on inquiry card.

DYNAMICALLY



Schematic diagram shows the M/59 Controller as installed in conjunction with Foxboro d/p Cell and M/53 Consotrol Recorder.



- **Valve Mounted** — screws directly on valve motor with heavy duty stainless steel ¼" fitting . . . eliminates "lag" commonly caused by transmission lines.
- **Fixed Settings** — exclusive live-balance design of the M/59 Controller permits fixed proportional and reset values for all flow conditions . . . for all valve motor sizes. (Reset can be field-adjusted for special purposes.)
- **Response** — amazingly fast recovery with precise control regardless of load conditions and process upsets. No control point drift. Unaffected by vibration or wide changes in ambient temperature.
- **Seal Valve** — optional feature which permits isolation of controller and remote manual control of process. Integrally mounted to the bottom of the controller.
- **Maintenance-free** — nothing to align, nothing to wear out. Flexure strip fulcrum eliminates friction and wear of conventional type pivots. Tightly gasketed, completely weatherproof.

Unique Live-Balance Design

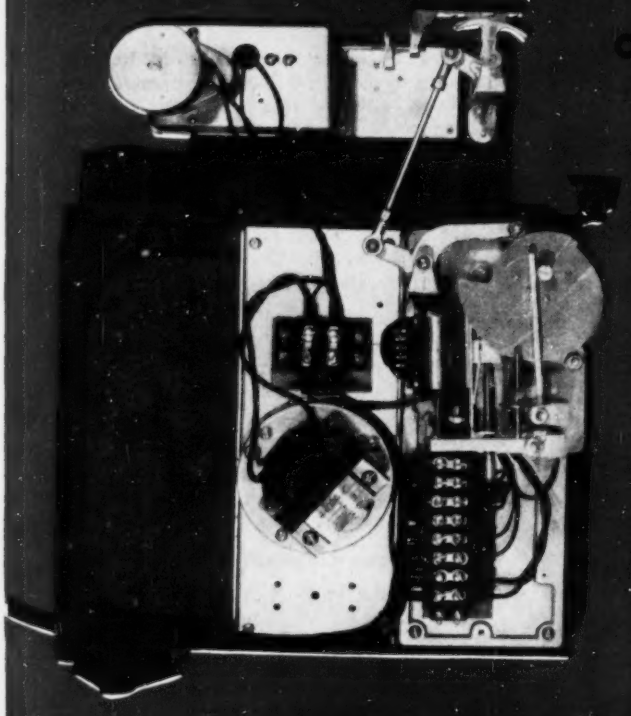
Photo of the M/59 with cover removed to show the exclusive, simplified live-balance mechanism. Balance Beam, which moves only a few thousandths of an inch to control the valve motor pressure, is flexure-pivoted and positioned between the four bellows. Any pressure unbalance between the set point and measurement bellows will change position of the Balance Beam. The proportional-reset bellows opposes such unbalance and prevents control point drift, while the fourth bellows provides the desirable amount of derivative action.

FOXBORO
REG. U. S. PAT. OFF.
INSTRUMENTS
INDICATING
RECORDING
CONTROLLING

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

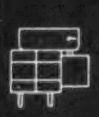
For further information circle 16 on inquiry card.

a new electronic flow meter!



Choice of 3 mercury-less transmitters

Hays Bernoulli flow or differential transmitter



Hays differential transmitter

Hays liquid level transmitter

continuous integration —no creep at zero

unaffected by normal voltage, frequency and temperature changes

electronic operation provides high speed and greater accuracy

3 to 1 range calibration at recorder

HAYS Electronic Flow Meter

Since the circuit is of the electronic null-balance type, it is unaffected by normal voltage and frequency variations. Also, neither temperature variations nor reasonable length of transmission lines affect the calibration of the instrument.

The *pen-drive motor* is built for reversing duty. Normal variations in voltage and frequency have no noticeable effect on its operation.

The *integrator* is continuous in operation and simple in mechanical construction. A micrometer zero adjustment for calibration is easily accessible.

Indicators can be calibrated to read directly in rate-of-flow or other factors as desired.

Write today for full information on the Hays Electronic Flow Meter Bulletin 52-1074-222.

Automatic Combustion Control
Boiler Panels • Hays-Penn Flowmeters
Veriflow Meters and Veritrol
Gas Analyzers • Draft Gages
Combustion Test Sets • CO_2 Recorders
Electronic Oxygen Recorders
Electronic Flowmeters
Electronic Feed Water Controls
Miniature Remote Indicators

THE hays CORPORATION

MICHIGAN CITY 8, INDIANA

For further information circle 17 on inquiry card.

It's VERSATILITY that sells SANBORN in the field of Industrial Recording

As indicated by references at the right, you may have a choice of five different instruments (A) for quick and convenient standard rack mounting in the system at A_1, PLUS a choice of up to four of any of the three different type amplifiers (B) or any combination of these amplifiers

with the

SANBORN FOUR-CHANNEL OSCILLOGRAPH RECORDING SYSTEM

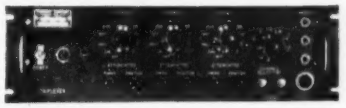
(MODEL 67)

A

DC PREAMPLIFIER

AC PREAMPLIFIER

DC CONVERTER—for low level DC recording such as thermocouple output.



TRIPLEXER—when coupled to a DC amplifier permits the recording of three events in one channel.

THRESHOLD MONITOR provides means for the control of voltage levels or rate of change.

B

DC (General Purpose) AMPLIFIER

STRAIN GAGE (Carrier) AMPLIFIER

SERVO MONITOR AMPLIFIER—a phase discriminating AC amplifier used in servo design and testing.

As shown in the diagram, removing or interchanging any of the amplifiers or other instruments is simply a matter of sliding the unit in or out of the mounting rack where contact is made automatically by plug-in connectors. Screws at the four corners of the panel hold the instrument in place.

Other features of this system which add to Sanborn VERSATILITY are the choice of eight paper speeds—50, 25, 10, 5, 2.5, 1.0, 0.5 and 0.25 mm/sec, and the use of either 4-, 2-, or 1-channel recording paper.

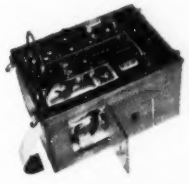
And, of course there are these popular Sanborn advantages: a high torque movement (200,000 dyne cms per cm deflection), direct *inkless* recording in *true rectangular coordinates*, and provision for code and time markings.

Sanborn Recording Systems may be used to record any one or more of a wide variety of phenomena whose characteristics range from static to 100 cycles per second. If your recording problem is not one which can be solved by standard Sanborn equipment, our engineers will be glad to suggest ways in which modifications of it may suit your requirements.

A complete catalog of Sanborn Industrial Recording Equipment will be sent gladly on your request.

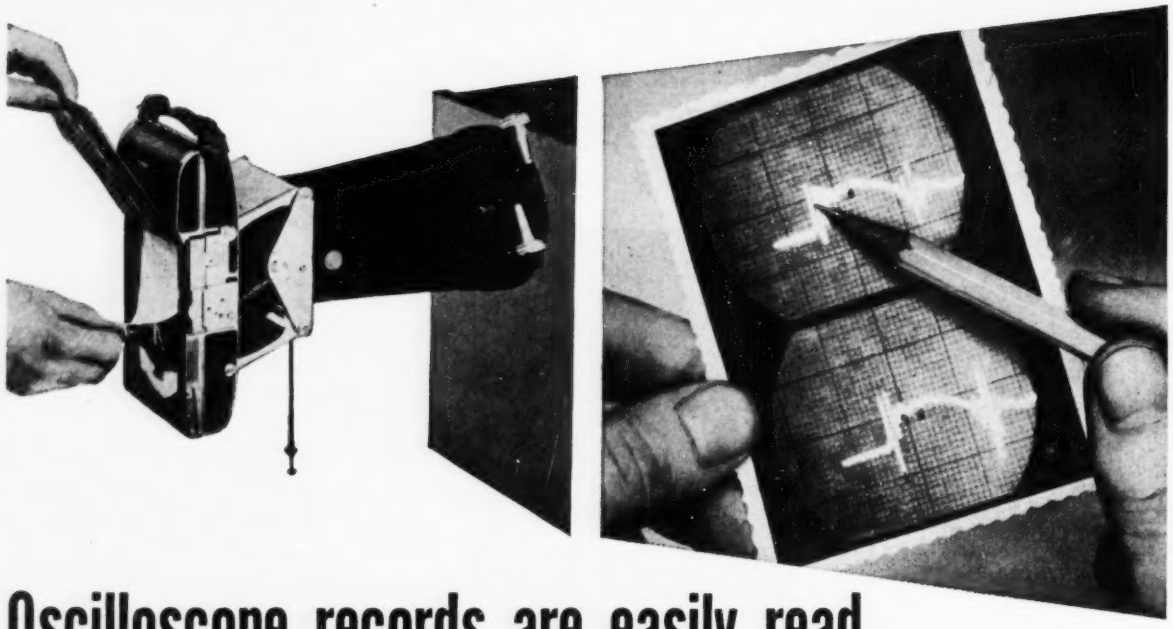
SANBORN COMPANY
CAMBRIDGE 39, MASS.

SANBORN 1-, AND 2-CHANNEL RECORDING SYSTEMS



One channel Model 128/141 above and two-channel Model 60 at right both incorporate Sanborn recording advantages which include interchangeability of amplifiers and (with Model 60) preamplifiers.

For further information circle 18 on inquiry card.



Oscilloscope records are easily read

when prints are made with the Fairchild-Polaroid® Oscilloscope Camera

There are three good reasons why oscilloscope traces can be read quickly and easily when they are photographed by Fairchild's adaptation of the Polaroid camera:

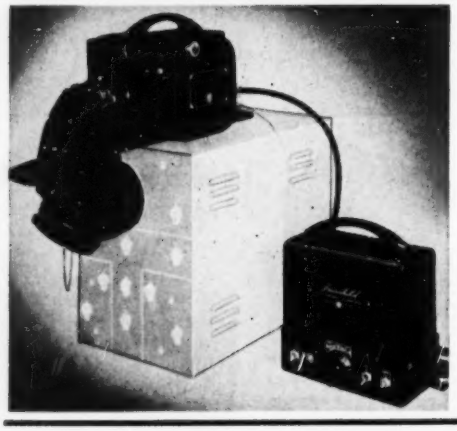
1 The trace reads normally—left to right—instead of reverse.

2 Reduction is exactly half life-size for easy measurement of values, especially when a grid is used.

3 Each print records two images, especially handy for before-and-after work.

Operation is as easy as 1-2-3. In two minutes or less you can set up the camera, snap the shutter, and pull the tab. Then you wait one minute more and remove the finished print. No focusing and no special training are required.

Important note—Delivery of Fairchild-Polaroid Oscilloscope Cameras can be had in just a few weeks. Write today for prices and information.



For still or continuous-motion recording on 35-mm film or paper Use the FAIRCHILD OSCILLO-RECORD CAMERA

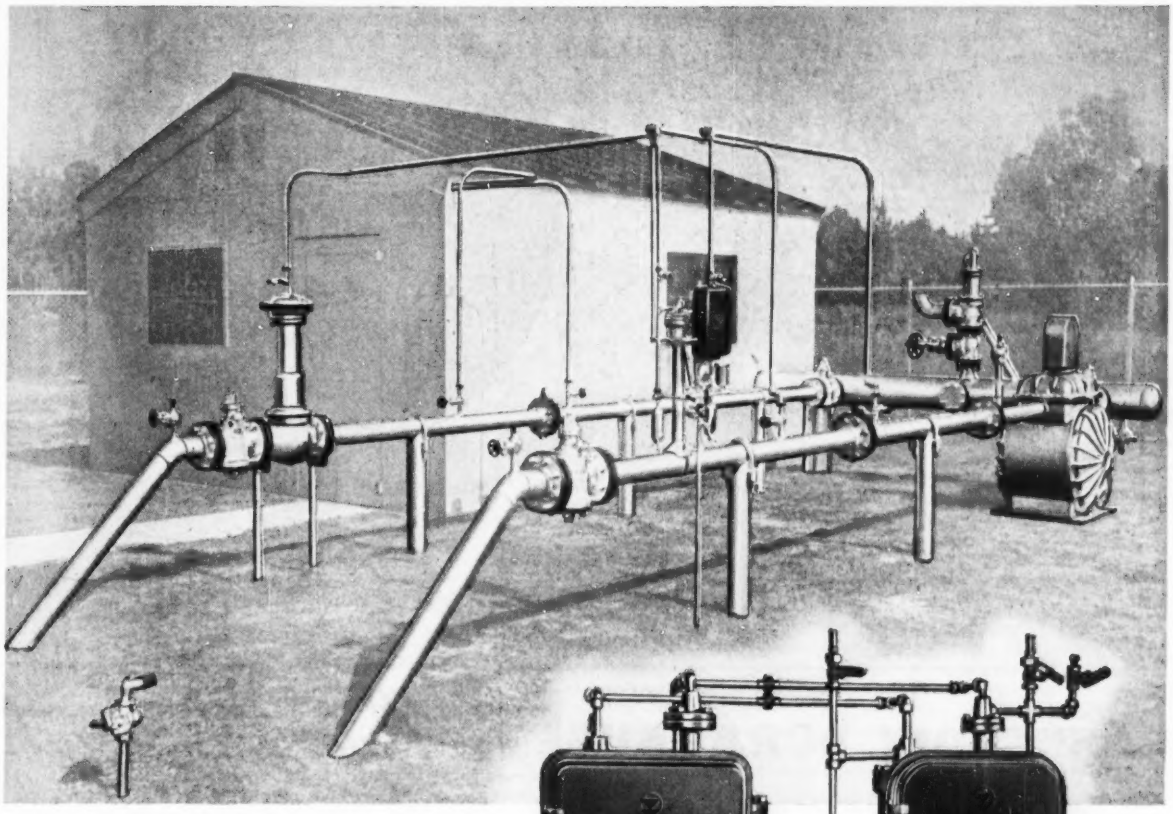
Speed is continuously variable through an exclusive electronic control. Film is sprocket-driven so there is no slippage. There are no belts or pulleys. Top-of-scope mounting eliminates need for tripod and keeps scope controls easily accessible. Provision for three film lengths—100, 400, or 1,000 feet. Delivery in about four months.

● Full information about the Fairchild-Polaroid and Oscillo-Record Cameras awaits your request. Write today to *Fairchild Camera and Instrument Corporation, Robbins Lane, Syosset, Long Island, New York, Department* 120-19 F1.

FAIRCHILD
OSCILLOSCOPE RECORDING CAMERAS

For further information circle 19 on inquiry card.

PRECISION GAS MEASUREMENT AT HIGH OR LOW FLOW RATES

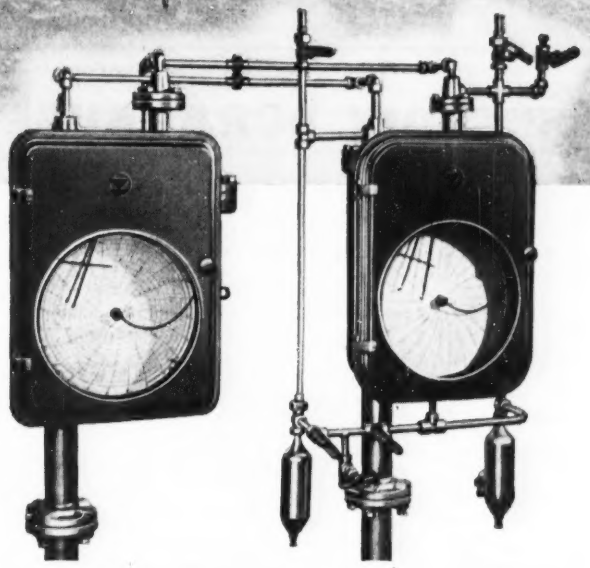


Southern Natural Gas Company Accurately Records Intermittent High and Low Volume Measurements.

Flow rates from zero to 154 thousand cubic feet of natural gas per hour are measured by this fully automatic measuring station.

An American® 500B, 250-pound Ironcase Displacement Meter measures flow rates up to 31,000 cubic feet per hour. Demand volume and meter pressure are recorded by a seven-day 100-pound American Volume and Pressure Gage.

A 100-inch Series A-88 American Differential Valve actuates a 4-inch Type CBVA Reliance Control Valve transferring approximately 80 percent of the flow to the orifice meter run when flow rates exceed the capacity of the Ironcase Meter.



This Duplex installation consisting of 20-inch — 100-inch Series A-88 American Westcott Orifice Meters records 80 percent of the flow at rates from 31 thousand to 154 thousand cubic feet at normal operating pressures of 50 pounds gauge pressure in the orifice meter run when used in the above combination with the 500B Meter.

AMERICAN® METER COMPANY

INCORPORATED ESTABLISHED 1892

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Albany • Alhambra • Atlanta • Baltimore • Birmingham
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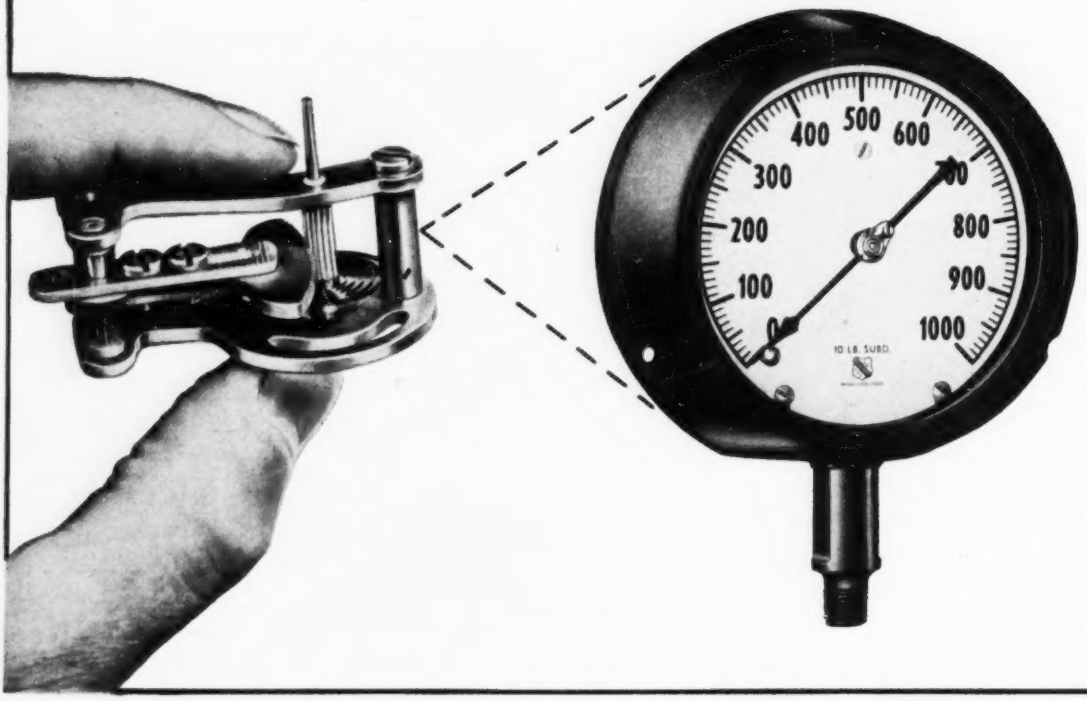
IN CANADA: Canadian Meter Company, Limited
Hamilton, Ontario • Edmonton, Alberta

For further information circle 20 on inquiry card.

LASTS FAR LONGER IN ANY SERVICE...



ASHCROFT DURAGAUGE WITH *Nylon Movement**

Nylon is light, strong, highly resistant to frictional wear. It absorbs vibration and doesn't corrode. It is dimensionally stable under high temperatures. That's why the bearings and pinion gear in the Ashcroft Duragauge movement are made of nylon. Mated with stainless steel parts and incorporating the rotary gear principle used in the finest watches, the result is a pressure gauge that gives longer service, sustained high accuracy and greatly improved sensitivity of indication.

The enduring dependability of precision-built Ashcroft Duragauges with Nylon Movement has been proved in the most "killing" services. Petroleum refineries, chemical plants and power stations know from experience that they *outlast all others.* So — if you want accurate pressure indication or recording to insure maximum safety, product quality, or cost control — install Ashcroft Duragauges. Your nearby Ashcroft Distributor will gladly help you select the proper Duragauges for your applications.

*Patented

Centralize Your Purchasing. Take advantage of the simplified buying procedures, low inventory investment and fast delivery service made possible by the facilities of your local Industrial Supply Distributor. Remember, he stocks hundreds of top-quality items and is your most reliable source for data on all that's new in time and money-saving products and methods.

1850 ASHCROFT U.S.A.

ASHCROFT GAUGES

MAXWELL MANNING & MOORE INC. TRADE MARK

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'ASHCROFT' GAUGES • 'HANCOCK' VALVES • 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN' INDUSTRIAL INSTRUMENTS. BUILDERS OF "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

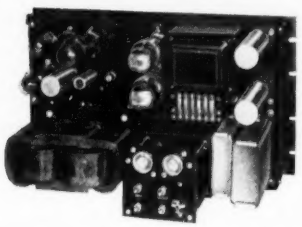
For further information circle 21 on inquiry card.

TO MAINTAIN CONSTANT OUTPUT VOLTAGES

STABILINE *Automatic* VOLTAGE REGULATORS

are available in 2 DISTINCT TYPES

TYPE IE INSTANTANEOUS ELECTRONIC



For the most exacting control featuring:

INSTANTANEOUS CORRECTION — as compared with any other type. Operation is entirely electronic without moving parts. Complete correction is effected in 3 to 10 cycles depending on variations in line voltage, load current, load power factor and other conditions.

EXCELLENT STABILIZATION AND REGULATION — The maximum change in output voltage will not exceed: ±0.25 per cent for any or all changes or variations in operating conditions — ±0.1 per cent for input voltage changes — ±0.15 per cent for load current or power factor changes from lagging 0.5 to leading 0.9.

MINIMUM WAVEFORM DISTORTION — Except under the most adverse conditions, distortion is usually under 2 per cent.

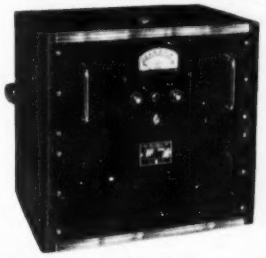
MUCH WIDER INPUT RANGE — than most competitive types. Ranges are 95-135 volts for a nominal output of 115 volts and 195-255 volts for a nominal output of 230 volts.

ADJUSTABLE OUTPUT VOLTAGE — Output from a nominally 115 volt unit is adjustable from 110 to 120 volts and from 220 to 240 volts on a nominally 230 volt unit.

INSENSITIVITY TO FREQUENCY CHANGES — but to maintain optimum correction characteristics, tolerances should not exceed ±10 per cent of the specified frequency.

STANDARD MODELS — are available in numerous ratings in capacities up to 5.0 KVA.

TYPE EM ELECTRO MECHANICAL



to control industrial loads — offer zero waveform distortion featuring:

UNUSUALLY HIGH EFFICIENCY — is an outstanding feature of the Type EM. It is comparable to that of the most conservatively designed fixed-ratio transformers.

ZERO WAVEFORM DISTORTION — is a primary requirement for many electronic applications. Type EM provides a constant output voltage which is a faithful and distortionless reproduction of the applied input waveform.

RAPID CORRECTION — Type EM is an electro mechanical device. While it does not correct instantaneously, it provides faster correction than most other automatic voltage regulators.

WIDE INPUT RANGE — is another important feature. Range is 95-135 volts for a nominally 115 volt unit; 195-255 volts for a 230 volt unit; 400-520 volts for the 460 volt units.

ADJUSTABLE OUTPUT VOLTAGE — Output from a 115 volt unit is adjustable from 110 to 120 volts; output from a 230 volt unit is adjustable from 220 to 240 volts; output from a 460 volt unit is adjustable from 420 to 460 volts.

INSENSITIVE TO FREQUENCY AND SYSTEM POWER FACTOR — Designed for 50/60 cycle power lines, all of the Type EM will perform satisfactorily at any frequency from 45 to 65 cycles. In addition, Type EM is insensitive to the magnitude and power factor of the load and has no effect on the system power factor.

STANDARD MODELS — are available for 115, 230 or 460 volt, 50/60 cycle, single and three phase operation in capacities up to 100 KVA.

. . . AND SPECIAL TYPES

application engineered to meet individual requirements

Specializing in the design, development and manufacture of Voltage Control Apparatus, The Superior Electric Company offers its experience to help in solving any voltage control problem. The Superior Electric Company is pleased to analyze your individual needs and will recommend the STABILINE Automatic Voltage Regulator best suited to your application.

SEND COUPON TODAY FOR BULLETIN S351 featuring engineering and application data on STABILINE Types IE and EM.

THE SUPERIOR ELECTRIC CO.
BRISTOL, CONNECTICUT

Manufacturers of

POWERSTAT VARIABLE TRANSFORMERS
STABILINE AUTOMATIC VOLTAGE REGULATORS
VOLTBOX A-C POWER SUPPLIES
• POWERSTAT LIGHT DIMMING EQUIPMENT
• VARICELL D-C POWER SUPPLIES
• SUPERIOR 5-WAY BINDING POSTS

THE SUPERIOR ELECTRIC CO.
705 MAE AVENUE, BRISTOL, CONN.

Please send my copy of Bulletin S351.

NAME _____

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CO. ADDRESS _____

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For further information circle 22 on inquiry card.

New

PERMANENT MAGNET DESIGN RESULTS IN A DOUBLE-BARRELED SAVINGS!

FOR TOP ENGINEERING COUNSEL ON PERMANENT MAGNETS CONSULT INDIANA

. . . Double-barreled Savings!

- **Lower first cost—70% saving**
- **Positive mechanical action— fewer service calls needed**

This is another example of how INDIANA's top engineering "know-how," secured from experience gained in successfully solving the design needs of over 35,000 permanent magnet applications, resulted in an improved product design.

You, too, can look to INDIANA for quality permanent magnets —for skill in manufacture—for cost cutting engineering aid. Rigorous quality control in every step of production is your assurance of exact magnetic and mechanical characteristics.

INDIANA is the only manufacturer furnishing all commercial grades of permanent magnet alloys. Furthermore, it has the ability and facilities to develop and produce the permanent magnets you require on a regular production schedule. For help with your problem, write INDIANA, today.

THE INDIANA STEEL PRODUCTS COMPANY
VALPARAISO, INDIANA

World's Largest Manufacturer of Permanent Magnets

DESIGN SUMMARY

Equipment
Telephone pay station manufactured by Automatic Electric Company, Chicago.

Application
Polarized coin return relay.

Situation
Automatic Electric previously used a chrome steel magnet. Automatic Electric and INDIANA engineers worked together in redesigning the permanent magnet assembly used in the polarized coin return relay, switching to the use of Alnico III material.

Results
1) An increase in flux of 27%—from 2750 Maxwells with old chrome steel magnet to 3500 Maxwells with Alnico III. 2) 70% Savings in cost of permanent magnet. 3) Saving in weight. 4) Simplified design and assembly. 5) Fewer service calls needed since, with the new design, a positive mechanical coin return action was secured—*permanently!*

To help you with your permanent magnet design problems, write for Design Manual No. 4-D5.

INDIANA PERMANENT MAGNETS

PERMANENT MAGNETS MAY DO IT BETTER

For further information circle 23 on inquiry card.

ELECTRONIC TEST INSTRUMENTS

-hp- 522B Electronic Counter

IS YOUR MEASURING PROBLEM HERE?

FREQUENCY	TIME INTERVAL
Production quantities	Elapsed time between impulses
Nuclear radiations	Pulse lengths
R.P.S. and R.P.M.	Camera shutter speed
Power line frequencies	Projectile velocity
Very low frequencies	Relay operating times
Frequency stability	Precise event timing
Oscillator calibration	Interval stability
Pulse repetition rates	Frequency rates
Weight, pressure, temperature, acceleration	Phase delay

Investigate this new, low-cost all purpose *-hp-* counter

This new electronic counter can save you time and money by speeding and simplifying research and manufacturing measurements. It is a compact, low-cost, extremely versatile instrument offering you accurate frequency, period *or* time measurements. It performs all functions without extra-cost modification. Results are displayed instantly and automatically in direct-reading form. Unskilled personnel can use the instrument immediately without training.

Model 522B measures rate of occurrences from .00001 to 100,000 per second. It measures time from 10 microseconds to 27.8 hours. Counting is available over periods of 1/1,000, 1/100, 1/10, 1 and 10 seconds or multiples. Stability of time base is 5 parts per million. Time of display can be varied to any duration, counts are automatically reset, action is repetitive. Results are presented direct in cps, kc, seconds or milliseconds. Decimal point is automatically indicated.

The instrument consists of five decade counters, a wide range time base plus gating and auxiliary circuits. The unknown is applied to the counters through the gate circuit. For frequency measurement this circuit remains open for a precise interval controlled by an oven-housed quartz crystal.

-hp- 522A Electronic Counter

For applications where wide-range frequency and period measurements are desired. Frequency counting facilities are identical with 522B, except gate time for frequency measurement is 1 second or multiples, and standard frequency counted for period measurement is 100 kc. Decimal point and time interval measuring circuits are omitted. $775.00

Data subject to change without notice. Prices f. o. b. factory

SPECIFICATIONS—MODEL 522B

FREQUENCY MEASUREMENTS:

Range: 10 cps to 100 kc.
Accuracy: ± 1 count ± stability (5/1,000,000 per week).
Registration: 5 places. Output pulse available to actuate trigger circuit for mechanical register to increase count capacity.
Gate Time: .001, .01, .1, 1, 10 seconds. Extendable to multiples of 1 or 10 seconds by manual control.
Display Time: Variable .1 to 10 seconds in steps of gate time selected. Display can be held indefinitely.

PERIOD MEASUREMENTS:

Range: .00001 cps to 10 kc.
Accuracy: ± .03% ± stability (for measurements over a 10 cycle period).
Gate Time: 1 or 10 cycle of unknown. Extendable to any number of cycles by manual control. (For frequencies under 50 to 60 cps.)
Standard Freq. Counted: 1, 10, 100 cps; 1, 10, 100 kc; or external.

TIME INTERVAL MEASUREMENTS:

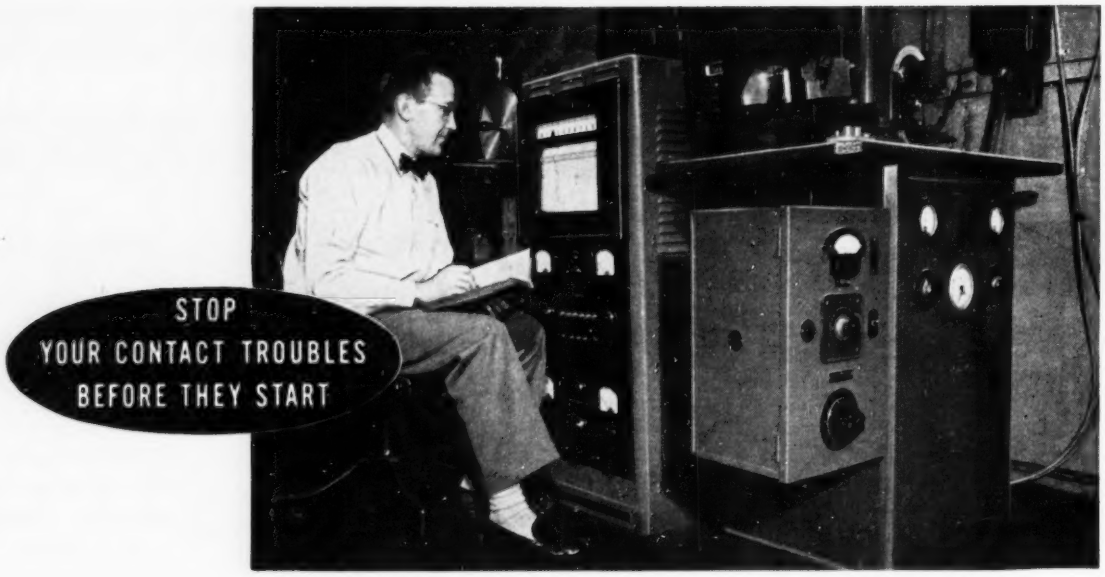
Range: 10 μsec to 100,000 seconds (27.8 hrs.)
Accuracy: ± 1/std. freq. counted ± stability.
Trigger Slope: Pos. or neg. on start and/or stop channels.
Trigger Amplitude: Continuously adjustable on both channels from −100 to +100 volts.
Standard Freq. Counted: 1, 10, 100 cps; 1, 10, 100 kc; or external.
Price: $900.00 f.o.b. factory.

Write for complete details

HEWLETT-PACKARD COMPANY
2707C PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U.S.A.
SALES REPRESENTATIVES IN ALL PRINCIPAL AREAS
Export: FRAZAR & HANSEN, LTD., New York • San Francisco • Los Angeles

Instruments for Complete Coverage

For further information circle 24 on inquiry card.



X-ray diffraction equipment in the Mallory Contact Engineering Laboratory. It is so sensitive it will identify contaminating films of less than a hundredth of a micron.

Less Than a Hundredth of a Micron!

The slightest trace of contaminating films on contact surfaces can be identified by X-ray diffraction equipment.

In a contact, trouble can be a lot of things. The paper used in packaging, the type of glue on sealing tape, insulation on a wire, atmospheric conditions . . . are just a few of the many things that can deposit a contaminating film on contact surfaces.

Because we have the equipment to identify contaminating films, we can track trouble to the source and correct it. This same X-ray diffraction equipment is also used in the development of new contact materials, by identifying unforeseen formations that may develop during production processes. It is used in life test work to study gradual changes taking place.

This is but one example of the complete facilities that are ready to go to work on your contact problems . . . whether it is a simple button contact or complex contact assembly that is involved. If you would like to improve the contacts in your products or produce them at lower cost, get in touch with us at your first opportunity. Our engineers will be glad to talk to you . . . answer your questions.

Expect more . . . Get more from **MALLORY**

In Canada, made and sold by Johnson Matthey and Mallory, Ltd., 110 Industry Street, Toronto 15, Ontario

Electrical Contacts and Contact Assemblies

P.R. MALLORY & CO. Inc.
MALLORY

SERVING INDUSTRY WITH THESE PRODUCTS:
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

P. R. MALLORY & CO. INC., INDIANAPOLIS 6, INDIANA

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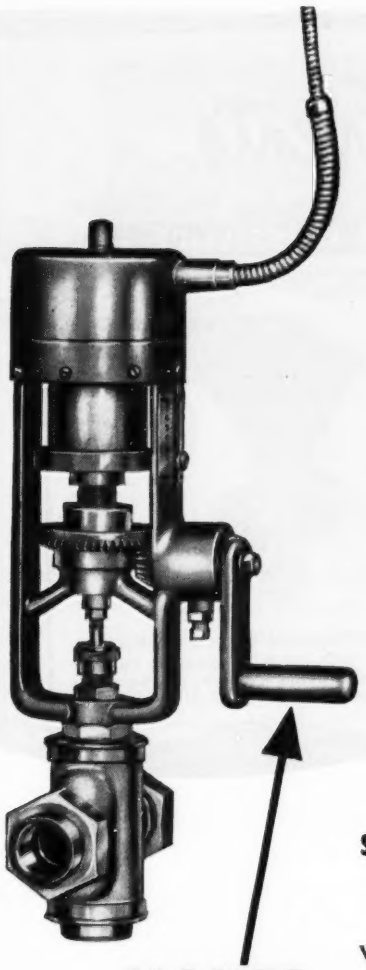


Sylphon Regulator No. 923-Q . . . quick, crank-adjusting

MAKES TEMPERATURE TO ORDER ...FAST!

With this Sylphon Regulator, you can make quick changes in process temperatures—control operations faster and better. A simple turn of the crank adjusts the temperature to the setting desired. It's much easier and more accurate than conventional hand-wheel type regulators, especially for batch processing.

You get *more* advantages with this Sylphon Regulator. Because it provides dependable, accurate temperature control, you are assured of uniform processing conditions. Wasteful overheating is prevented. Spoilage is reduced. Manpower, man hours and fuel are saved.

Sturdy, neat and compact, No. 923-Q is built to give you years of trouble-free, reliable service. Used with open and closed tanks, bottle washers, glue kettles, dish-washing machines, slashers and other processing units. Ideal as standard equipment.

Write for information about Regulator No. 923-Q—or about other Sylphon Regulators that meet temperature control requirements for any industrial need. Ask for Catalog JE-A.

"Everything's Under Control"

FIRST WITH BELLOWS

Temperature Controls • Bellows Devices • Bellows Assemblies

FULTON SYLPHON
DIVISION

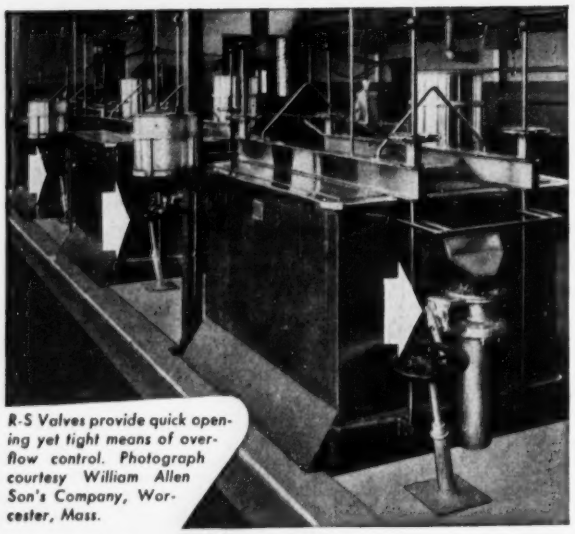
ROBERTSHAW-FULTON CONTROLS CO. KNOXVILLE 4, TENN.

Canadian Representatives, Darling Brothers, Montreal

For further information circle 26 on inquiry card.

R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •

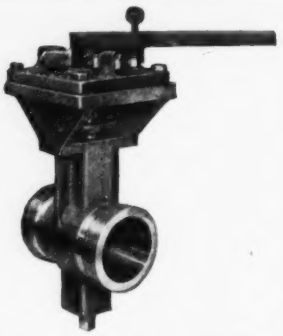


R-S Valves provide quick opening yet tight means of overflow control. Photograph courtesy William Allen Son's Company, Worcester, Mass.

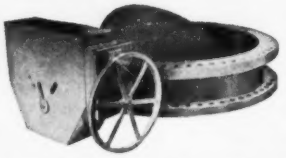
Specify R-S VALVES

- for simplified and economical control and shut-off of volume and pressure
- with metal to metal seat including babbit or rubber seat
- for manual or any type of automatic control
- for any material that flows or is forced through a pipe
- in any material that can be cast or welded including plastics and certain alloys especially adapted to resist corrosion, erosion and temperature.
- in all sizes for all industries and processes, and in the temperature range from minus 300° to plus 2000° F. 2 to 2500 psig.

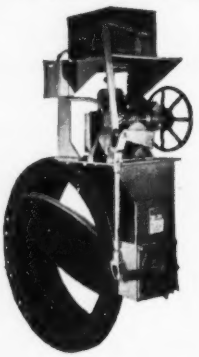
Representatives are listed in telephone directories as: "R-S Products Corporation Valves".



No. 674—Special 2½-inch stainless steel valve with 150 psi construction. Standard sanitary type threads. Heavy duty handlever assembly Type No. 681.



No. 848—Heavy duty valve with rubber seat for water service at high velocity. Handwheel operates valve through spur gear and pinion into a threaded reach rod (enclosed Type No. 700) in order to obtain sufficient torque to seat disc in rubber.



No. 847—Heavy duty valve with electric motor operator mounted directly above valve and positioned by pressure controller mounted above the motor.

Consult your local R-S Valve Engineers, or write direct.

R-S PRODUCTS CORPORATION • 4600 Germantown Ave., Philadelphia 44, Pa.

An S. Morgan Smith Company Subsidiary

DISTRICT OFFICES IN PRINCIPAL CITIES

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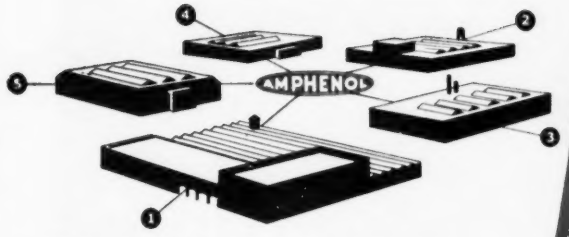


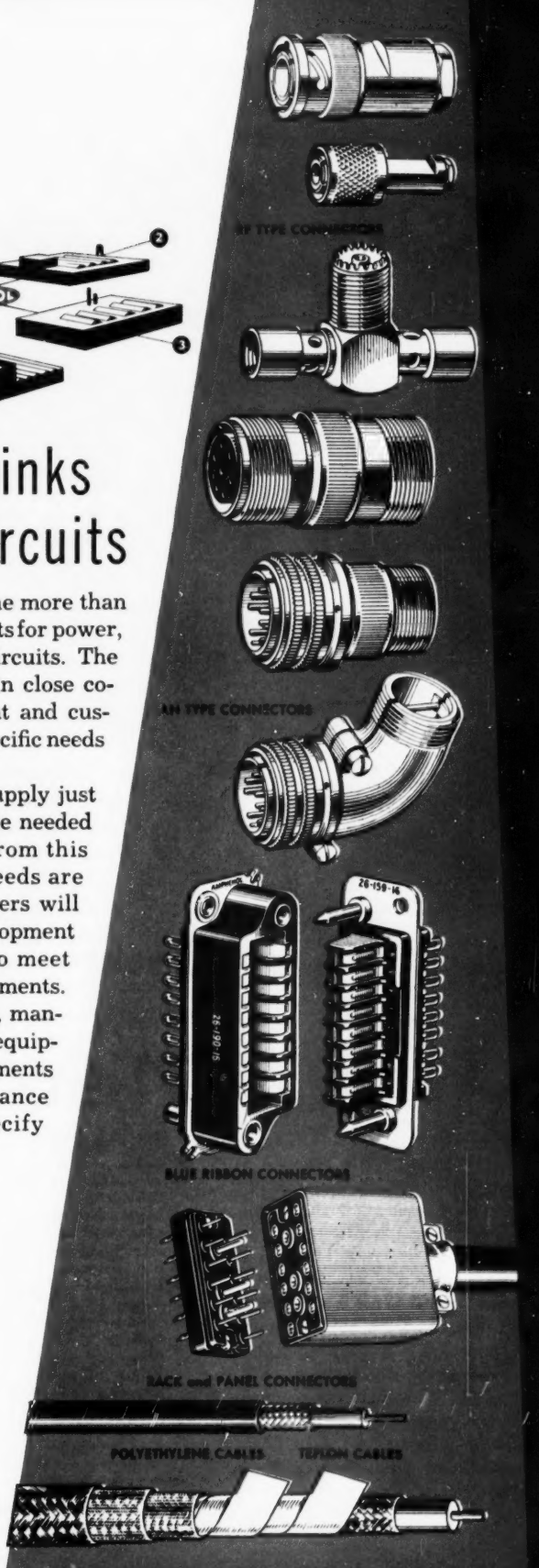
for critical links in quality circuits

Shown here are a few of the more than 9,000 AMPHENOL components for power, control and instrument circuits. The majority were developed in close co-operation with government and customer engineers to meet specific needs in the electronic industry.

AMPHENOL can usually supply just the right connector or cable needed for a particular circuit from this wide selection. If your needs are special, AMPHENOL Engineers will work with you in the development of a custom component to meet your most exacting requirements.

Whether for product use, manufacturing and testing equipment or laboratory instruments—long, efficient performance is assured when you specify AMPHENOL components.

Specify AMPHENOL components



RACK and PANEL TYPE CONNECTORS

AN TYPE CONNECTORS

RF TYPE CONNECTORS

AUDIO CONNECTORS

POWER PLUGS

BLUE RIBBON CONNECTORS

INDUSTRIAL SOCKETS

MINIATURE SOCKETS

TUBE SOCKETS and RADIO COMPONENTS

MICROPHONE CONNECTORS

RG COAXIAL CABLES

TEFLON and POLYETHYLENE CABLE and WIRE ASSEMBLIES

PLASTICS EXTRUDED and INJECTION MOLDED

Write today for your copy of General Catalog B-2

AMERICAN PHENOLIC CORPORATION
chicago 50, illinois

For further information circle 28 on inquiry card.

AT THE PUSH OF A BUTTON...

Once you zero-set a new Du Mont Type 304-A it is almost automatic to measure potentials of the waveforms on the screen of the cathode-ray tube. And you'll be surprised to find out how much more you know about your circuit; how much easier circuit development and production testing become when amplitude calibration is in front of you every time you examine a waveform. The new Du Mont Type 304-A will make your job easier, will greatly simplify measurements that formerly were difficult or inconvenient to make. The Type 304-A is not just another oscillograph; it is a true cathode-ray voltmeter, made possible by a precision calibrator and the tight-tolerance, flat-face Type 5ADP- Cathode-ray Tube. Only through the combined facilities, unique in the industry, of the Du Mont Cathode-ray Tube and Instrument Divisions could the Type 304-A Cathode-ray Oscillograph have evolved.

SPECIFICATIONS:

- Tight-tolerance, flat-face Type 5ADP- Cathode-ray Tube
- Vertical and horizontal amplifiers flat to d.c., 10% down at 100 KC
- Direct voltage measurement — Range, 0.1 to 1000 volts full scale, read directly from oscillograph scale; 5% overall accuracy
- High sensitivity — At full gain, 0.025 volts/inch
- Undistorted vertical and horizontal deflection more than 4 inches
- Expansion equivalent of 20 inches vertically and 30 inches horizontally with full positioning
- Driven and recurrent sweeps with sync limiting — Range, 2 to 30,000 cps; provision for extra-low frequency sweeps by externally connected capacitor; maximum writing rate, 1 inch/μsec
- Illuminated, numbered scale and suitable filter provided; scale illumination variable from zero to more than adequate for viewing and photography
- Improved stability of vertical amplifier

Price $333.00

DU MONT INSTRUMENT DIVISION, ALLEN B. DU MONT LABORATORIES, INC., 1500 MAIN AVE., CLIFTON, N. J.

For further information circle 29 on inquiry card.

Tops for HIGH PRESSURES

Atkomatic SOLENOID

HIGH PRESSURE ELECTRIC VALVES

ATKOMATIC HIGH PRESSURE VALVES are designed to handle pressures to 3,000 psi. Standard AC and DC voltages. Sizes range from ¼", ½", ¾", 1" and 1½ inches.

Valves are globe type, pilot operated, piston actuated with only 3 moving parts. Suitable for operations on air, gas, oil, water, etc.

Optional equipment includes explosion proof coil housings made of heavy cast iron available in all sizes.

Bubble tight pilot valve assembly available for operations where leakage cannot be tolerated. This assembly eliminates metal-to-metal Pilot valve seat seal.

Use coupon below . . . *write today for more information.*

REPRESENTATIVES WANTED

Atkomatic Valve Company has some territories available for Manufacturer's Representatives. For further information write to General Manager, Atkomatic Valve Company, 545 Abbott Street, Indianapolis 25, Indiana.

LOOK TO . . .

Atkomatic

SOLENOID

ELECTRIC VALVES

ATKOMATIC VALVE COMPANY
555 Abbott Street, Indianapolis 25, Indiana

Gentlemen: Please send more information on the Atkomatic Solenoid High Pressure Electric Valves.

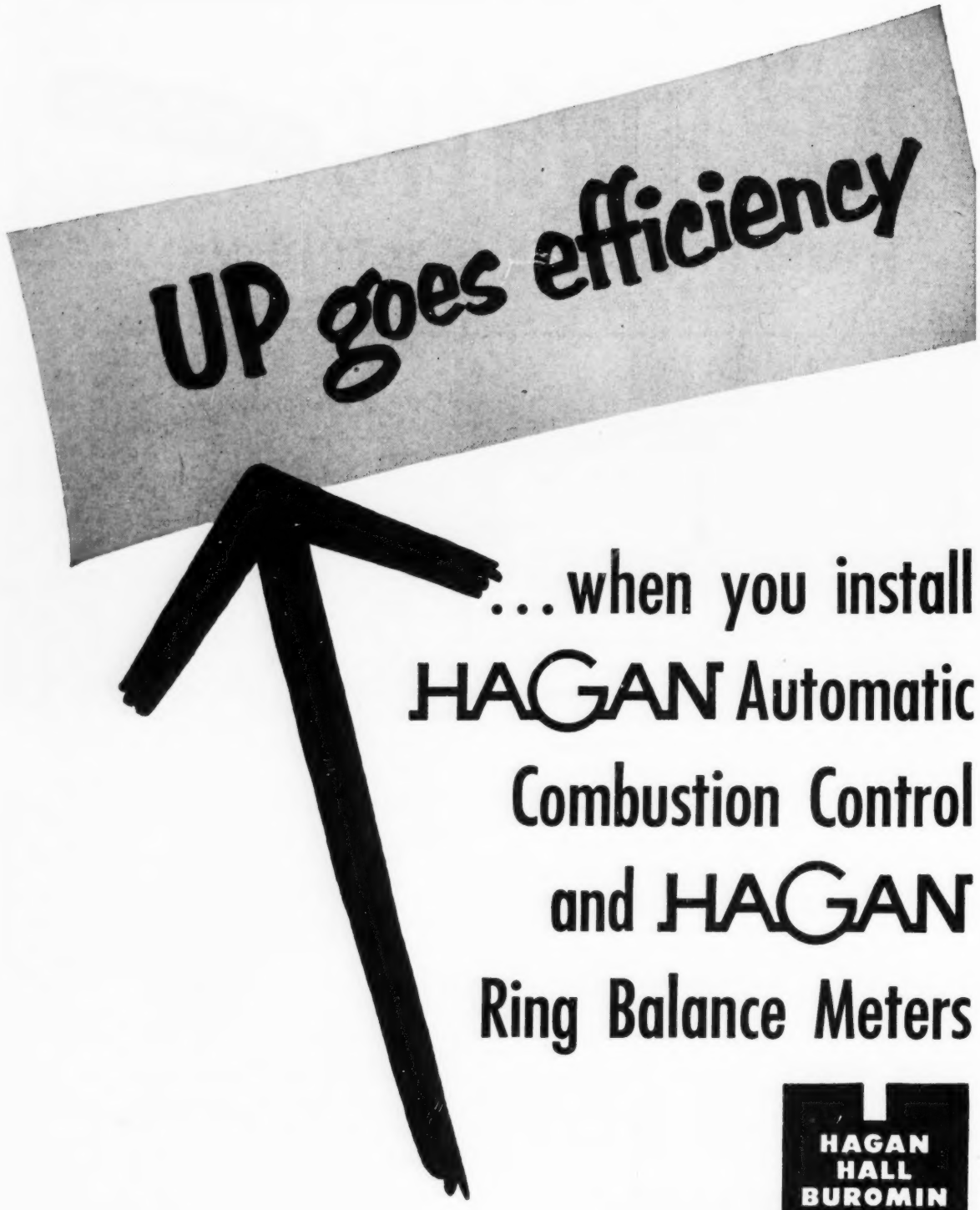
Name.....*Title*.....

Company.....

Address.....

City.....*State*.....

For further information circle **30** on inquiry card.



...when you install
HAGAN Automatic
Combustion Control
and HAGAN
Ring Balance Meters

HAGAN
HALL
BUROMIN
CALGON

For further information circle 31 on inquiry card.

When you install Hagan Automatic Combustion Controls and Hagan Ring Balance Flow Meters, you are certain of accurate and dependable results, low maintenance costs, increased efficiency and economy of operation.

A system of Hagan Automatic Combustion Control is available for your plant, regardless of the number or size of boilers, steam pressure and temperature, or the combination of fuels to be controlled.

Whether your plant operation requires indications, records, or totalizations of flow, in any combination, there is a Hagan Ring Balance Meter built for the job. Any fluid flow—steam, water, liquid fuels, gases, compressed air—can be measured at any pressure up to 15,000 psig. Automatic temperature and pressure compensation of flow readings are available. Two flow readings can be added or subtracted in a single meter.

For combustion control and metering systems which are versatile, accurate, and durable, install HAGAN. Our engineers will be glad to show you what HAGAN Combustion Controls and HAGAN Ring Balance Meters can do.

HAGAN CORPORATION

HAGAN BUILDING, PITTSBURGH 30, PA.

BOILER COMBUSTION CONTROL SYSTEMS
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
METALLURGICAL FURNACE CONTROL SYSTEMS
CONTROL SYSTEMS FOR AUTOMOTIVE AND
AERONAUTICAL TESTING FACILITIES

For further information circle 31 on inquiry card.

Where can YOU use these unusual

Since their introduction less than two years ago, Masoneilan 60000 Series Controllers have won wide acceptance through superior performance, great versatility, and simplicity of adjustment and operation. We believe that you, too, will like these "Instrument Man's Instruments" once you have seen them.

The Proportional-Reset Controller
Note that all settings are accessible without removing chart.

A HIGH Cq (Quality Coefficient) PRODUCT

For further information circle 32 on inquiry card.

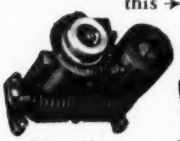
Pneumatic Controller Advantages?

Consider versatility for example. In *one* instrument you can obtain *all* these...

ON-OFF CONTROL
simply by setting the Proportional Band Wheel to minimum proportional band — like ← this. Action may be either direct or reverse.

DIFFERENTIAL GAP CONTROL
by turning the Proportional Band Wheel to the "Gap" quadrants, either direct action like ← this or reverse action like this →

PROPORTIONAL CONTROL
by setting the Proportional Band Wheel to the required proportional band in the direct action quadrant like ← this or the reverse action quadrant like this →

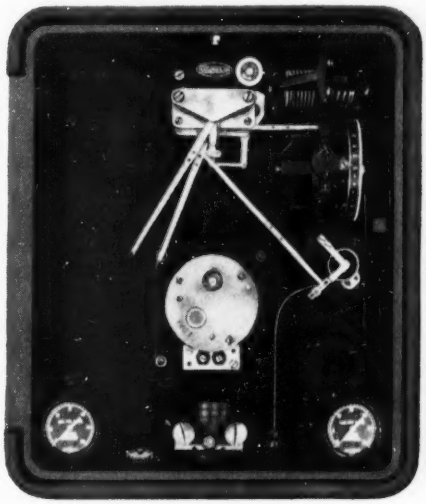


Reset Unit

Proportional Unit

PROPORTIONAL-RESET CONTROL
by substituting the Reset Unit for the Proportional Unit. No piping changes — you simply plug in the unit, realign (one adjustment), turn Proportional Band Wheel to desired direct or reverse action quadrant, and set required reset rate.

Or if versatility is not important to you, consider these advantages to the Instrument Man—



PILOT — of amplifying, balanced type is easily serviced because of its simple construction and cleanable orifice.

MANIFOLDED AIR PASSAGES — with plug-in connections, eliminate pressure fittings and clutter of tubing; facilitate interchangeability of individual subassemblies and accessibility of adjustments.

NOZZLE — is *easily* removed, cleaned, replaced and calibrated.

MINIMUM OF ADJUSTMENTS — with large knobs or wheels provided for making them; plus easily read scales to aid in settings.

SIMPLICITY — of unit subassemblies, and of their arrangement, for ease of adjustment and servicing.

If you have not already seen these controllers we suggest you arrange for a demonstration in your own office or plant. Simply write or telephone our office nearest you. It will help to solve *your* control problem.

MASON-NEILAN
REGULATOR COMPANY
1210 ADAMS STREET, BOSTON 24, MASS., U. S. A.

Sales Offices or Distributors in the Following Cities: New York • Syracuse • Chicago • St. Louis • Tulsa • Philadelphia • Houston Pittsburgh • Atlanta • Cleveland • Cincinnati • Detroit • San Francisco • Boise • Louisville • Salt Lake City • El Paso • Albuquerque Charlotte • Los Angeles • Corpus Christi • Denver • Appleton • Birmingham • New Orleans • Dallas • Seattle
Mason-Neilan Regulator Co., Ltd., Montreal and Toronto

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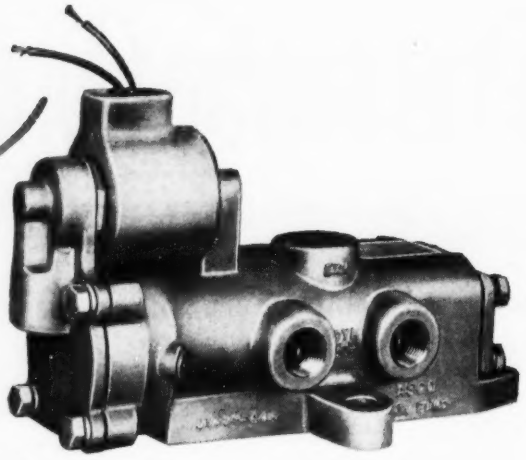
Announcing

The New "Super-Duty"
4 Way Poppet Type
High Speed Solenoid Valve
Produced by ASCO



Headquarters for Solenoid Valves and Electromagnetic Controls

Type — 4 Way Valve, Screwed Pipe Connections or Manifold Mounting. Available for 5 ported operation and regulated flow control.

Use — Controlling Ultra High Speed Double Acting Pneumatic or Hydraulic Cylinders.

Operating Speed with Air, 500 Cycles/Minute Continuous; 750 Cycles/Minute Intermittent.

Design Features

- **Instantaneous Action.**
- **Poppets on Common Shaft operated by line pressure inherently provide simultaneous valve action and tight seating.**
- **Differential Piston provides power operation in both directions. Eliminates all danger from sticking.**
- **Short Strokes; Guided Inserted Seats; Minimum Wear.**
- **Packless Construction—No Stuffing Boxes or Sliding Glands.**

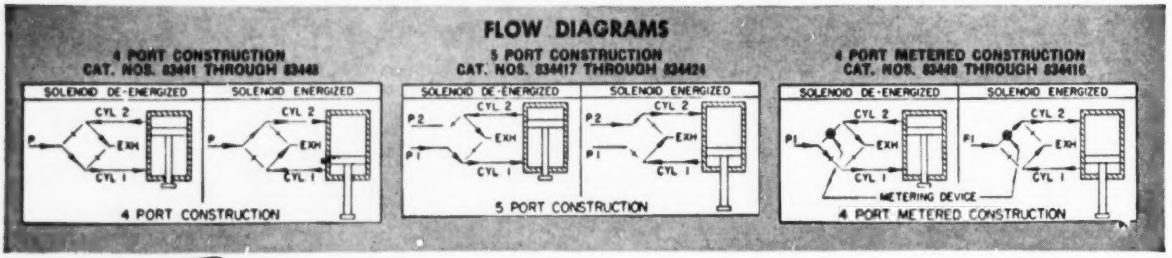
This Solenoid Valve has been thoroughly tested at High Speed for millions of operations.

This Valve (Bulletin 8344) comes with mill type construction, corrosion-resistant bronze body and stainless steel seats and discs. Four standard sizes are available; ⅜, ½, ¾, and 1 inch. The compactness of the Valve is indicated by the dimensions of the largest (1 inch) unit; length 11½ inches, width 5⅜ inches, height 5¹⁵⁄₁₆ inches. The standard solenoid is suitable for NEMA Type IV Watertight and for Underwriters' Class 1, Group D, Explosion-Proof (NEMA Type VII) requirements. Standard valves suitable for pressures up to 250 psi, may be adapted to higher pressures, if required.

In writing for prices, delivery, and other information, tell us about your control problem. We have many other varieties of standard Solenoid Valves, and engineering facilities for designing special types should you need them.

We manufacture a complete line of standard and specialized Electromagnetic Controls. These include Automatic Transfer Switches, Remote Control Switches, Contactors, Relays, and complete Control Panels.

FLOW DIAGRAMS



ASCO Solenoid VALVES

"Serving Industry For Sixty-Five Years"

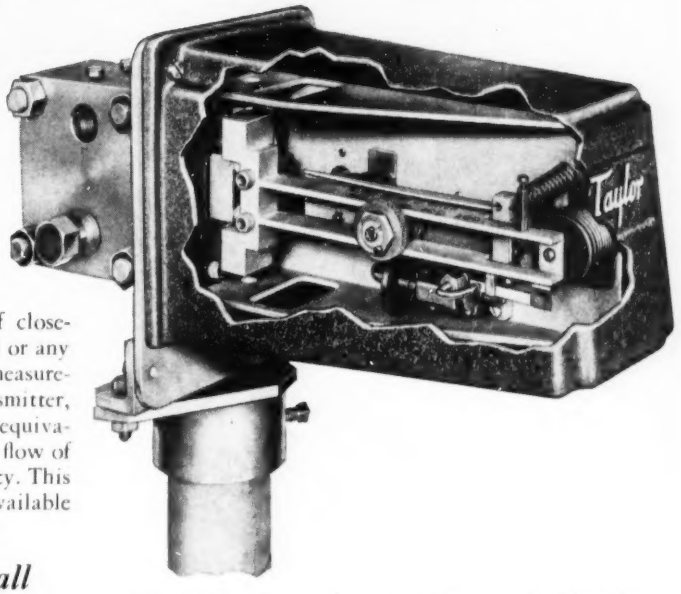
Automatic Switch Co.

385-T LAKESIDE AVENUE, ORANGE, NEW JERSEY

For further information circle 33 on inquiry card.

Taylor announces SIMPLIFIED FLOW MEASUREMENT

—with the NEW Taylor TRANSAIRE® Differential Pressure Transmitter!



HERE'S Taylor's answer to the problem of close-coupled fluid flow measurement, liquid level or any other installation requiring differential pressure measurement and transmission. It is a force-balance transmitter, designed to convert differential pressure into an equivalent 3 to 15 psi output. It can be used to measure flow of liquid, steam or gas; liquid level or specific gravity. This Transmitter has a 1500 psi pressure rating and is available in any desired range, from 20″ to 800″ of water.

Inexpensive and Simple to Install

1. Simplified piping because it can be close-coupled to orifice flanges.
2. No Leveling—mercuryless dry meter.
3. Side, top or bottom bracket mounting available with 2″ pipe stand.
4. No seal pots required—Negligible displacement because of force-balance construction.
5. Light weight for easy handling; weighs only 23 lbs.
6. Vent screws for simple, solid filling.

Enonomical—Easy to Maintain

7. Self draining or venting—no periodic manual venting or draining.
8. Mercuryless—flexible but tough Teflon coated glass fabric diaphragm.
9. Over-range to full body rating with no permanent damage.
10. Purges, if required, can be installed to keep body swept clean.
11. Simple range change by sliding pivot—screw driver trim.

Accurate

12. Relay valve for linearity, minimum hysteresis, fast speed of response.
13. Pressure effect 0.2% / 100 psi.
14. Temperature effect 1.0% / 100°F.
15. Self draining and venting. No errors build up during operation.
16. Damped pneumatic circuit—stable air output even on vibrating pipe lines.

Rugged and Dependable

17. Body forged steel or type 430 Stainless Steel. Working pressure rating, 1500 psi.
18. Weather-proof housing built for tough service and outdoor mounting.
19. Force-balance construction—negligible motion—minimum possible wear.
20. Process sealing bellows 3-ply type 316 stainless steel.

Adaptable

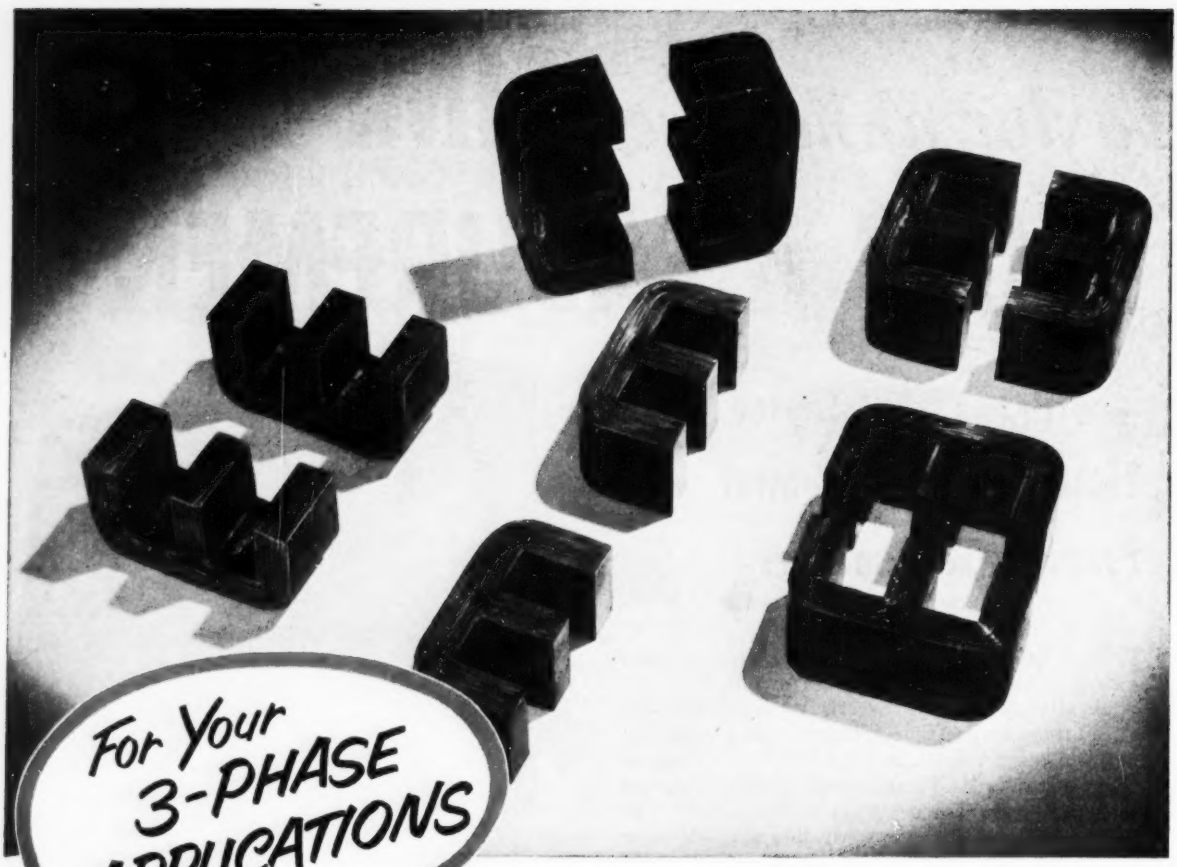
21. 100% suppression—continuously adjustable from 0 to 100%. Ideal for liquid level applications.
22. Ten-to-one rangeability in each of 2 forms:
    a. 20-200″ water, b. 80-800″ water.

Find out more about this latest addition to Taylor's three-part TRANSET* System. Ask your Taylor Field Engineer, or write for **Bulletin No. 98226.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.

TAYLOR INSTRUMENTS MEAN ACCURACY FIRST

For further information circle 34 on inquiry card.

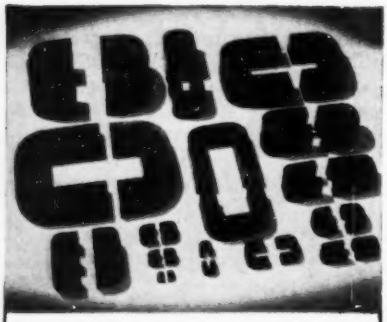


For Your 3-PHASE APPLICATIONS

Arnold E-CORES

made from SILECTRON strip
(grain-oriented silicon steel)

The use of "E" cores, wound from grain-oriented silicon steel, results in weight and size reduction as well as higher efficiency and possible cost savings. "E" cores can be supplied in a variety of window sizes and core areas from 1, 2, 4 or 12-mil Silectron strip, for high or low frequency 3-phase applications. ● All Arnold cores are made by precision methods, and carefully tested under closely controlled conditions to assure highest quality and reliability. *We'll welcome your inquiries.*



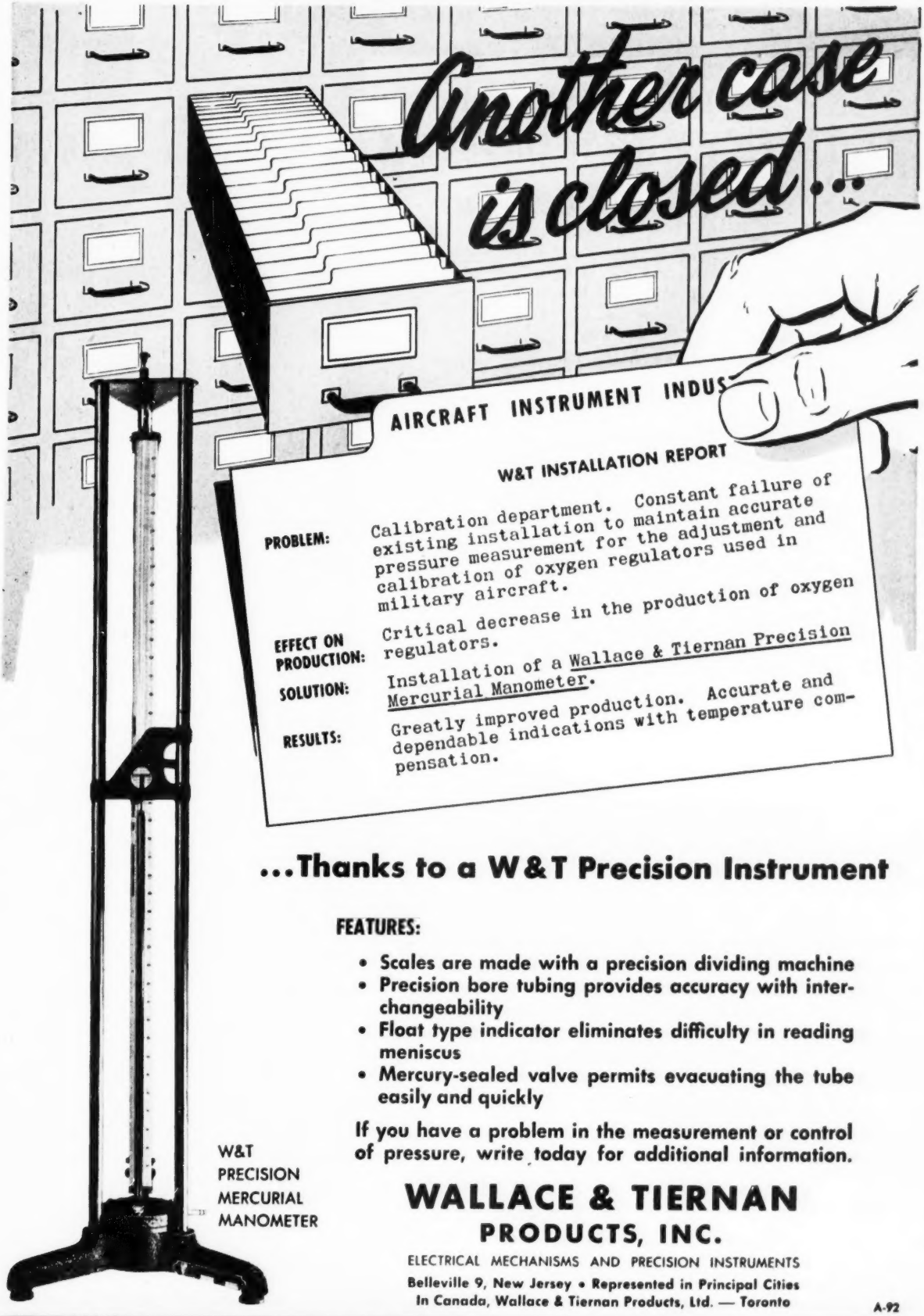
C-Cores to meet any requirement
For your single-phase applications, Arnold "C"-Cores are available in any shape and quantity, and in any size from fractions of an ounce to hundreds of pounds . . . wound from Silectron strip in a wide range of ultra-thin and heavier gauges. (Sizes up to 10 lbs. in 12-mil strip; to any weight in thinner gauges.)

WRITE FOR BULLETIN TC-105

WAD 4658

THE ARNOLD ENGINEERING COMPANY
SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION
General Office & Plant: Marengo, Illinois
DISTRICT SALES OFFICES
New York: Empire State Bldg. Los Angeles: 3450 Wilshire Blvd.

For further information circle 35 on inquiry card.


Another case is closed...
AIRCRAFT INSTRUMENT INDUS
W&T INSTALLATION REPORT
PROBLEM: Calibration department. Constant failure of existing installation to maintain accurate pressure measurement for the adjustment and calibration of oxygen regulators used in military aircraft.
EFFECT ON PRODUCTION: Critical decrease in the production of oxygen regulators.
SOLUTION: Installation of a Wallace & Tiernan Precision Mercurial Manometer.
RESULTS: Greatly improved production. Accurate and dependable indications with temperature compensation.

...Thanks to a W&T Precision Instrument

FEATURES:

- Scales are made with a precision dividing machine
- Precision bore tubing provides accuracy with interchangeability
- Float type indicator eliminates difficulty in reading meniscus
- Mercury-sealed valve permits evacuating the tube easily and quickly

W&T PRECISION MERCURIAL MANOMETER

If you have a problem in the measurement or control of pressure, write today for additional information.

WALLACE & TIERNAN PRODUCTS, INC.

ELECTRICAL MECHANISMS AND PRECISION INSTRUMENTS

Belleville 9, New Jersey • Represented in Principal Cities
In Canada, Wallace & Tiernan Products, Ltd. — Toronto

A-92

For further information circle 36 on inquiry card.

Here's why it pays *to know your*

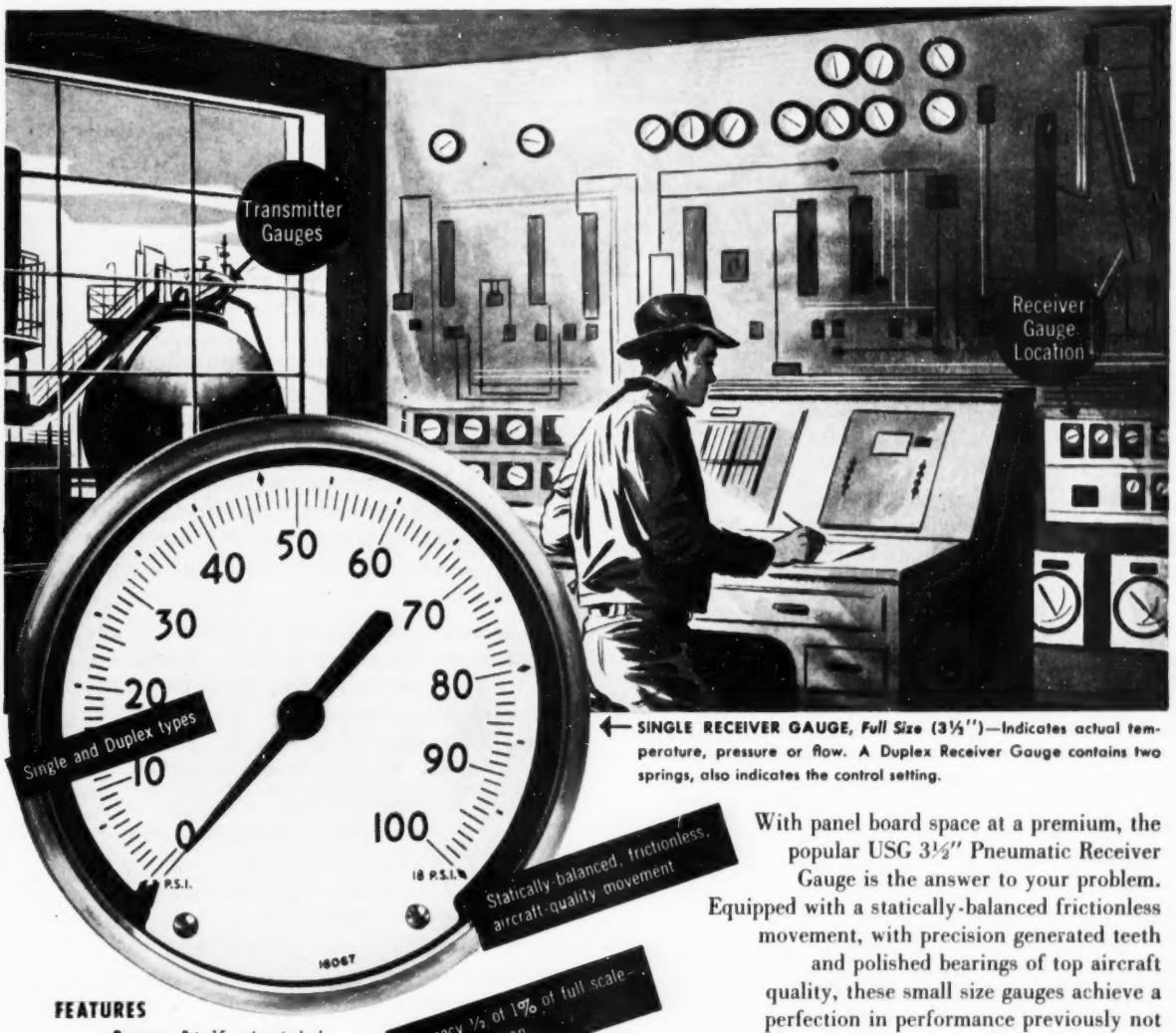
T. J. BARTKO, Honeywell Supplies Man in the Pittsburgh area, points out to Mr. E. H. Tittle, instrument department foreman at Crucible Steel, Midland, Pa., the heavy-duty construction of Brown asbestos covered thermocouple extension wire.

Your local HSM will gladly tell you about the new and improved types of extension wires for your own plant's applications, which are available for delivery from stocking points convenient to you. And he'll welcome the opportunity to explain how planned buying—the HSM way—can bring new convenience and economy to all your purchasing of pyrometer supplies. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4482 Wayne Ave., Philadelphia 44, Pa. Stocking points in Philadelphia, Cleveland, Chicago, Atlanta, Houston, Los Angeles and San Francisco.

● **REFERENCE DATA: Write for Pyrometer Supplies Buyers' Guide No. 100-4.**

Read pressure, temperature or flow at a distance with USG Pneumatic Receiver Gauges



← **SINGLE RECEIVER GAUGE, *Full Size* (3½")**—Indicates actual temperature, pressure or flow. A Duplex Receiver Gauge contains two springs, also indicates the control setting.

With panel board space at a premium, the popular USG 3½" Pneumatic Receiver Gauge is the answer to your problem. Equipped with a statically-balanced frictionless movement, with precision generated teeth and polished bearings of top aircraft quality, these small size gauges achieve a perfection in performance previously not thought possible of a pressure gauge.

FEATURES

Ranges:	3 to 15 p.s.i.g. stocked, 3-18 p.s.i.g. also available.
Scale:	A variety of scales available.
Case Diam.:	3¾"
Bezel Opening:	3⅛"
Pressure Elements:	Phosphor Bronze, AAA width, stress-relieved.
Movement:	Aircraft quality — phosphor bronze and stainless steel.
Adjustments:	±1% maximum linearity adjustment with adjustable tip; micro-adjustable pointer permits rotation with respect to pinion for zero adjustment.
Stops:	Zero and over-range.
Case:	Drawn steel, black crinkled finish, bevelled glass.
Socket:	Extruded brass.

SINGLE OR DUPLEX TYPES—The USG Receiver Gauge is graduated to the same scale as the transmitter gauge yet operates at a very small pilot pressure. It is available with a single spring or double spring (Duplex Receiver Gauge).

GAUGES CARRIED IN STOCK—USG Receiver Gauges are stocked without dials in the range of 3-15 lbs. This permits easy assembly and quick shipment of gauges with dials calibrated to your choosing. Single-spring gauges are available in ¼" low male or center back connection. Duplex gauges are available in low back connection with ⅛" or ¼" male pipe thread and 5/16-28 tubing connection.

United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Pa.

UNITED STATES GAUGE

Quality Gauges Engineered for Enduring Accuracy

PRODUCTS OF UNITED STATES GAUGE... Absolute Pressure Gauges • Aircraft Instruments • Air Volume Controls • Altitude Gauges • Boiler Gauges • Chemical Gauges • Mercury, Gas, and Vapor Dial Thermometers • Glass Tube and Industrial Thermometers • Flow Meters • Inspectors' Test Gauges • Precision Laboratory Test Gauges • Marine, Ship and Air-Brake Gauges • Voltmeters • Ammeters • Welding Gauges

OTHER DIVISIONS OF AMERICAN MACHINE AND METALS, INC., AT SELLERSVILLE, PA.:
GOTHAM INSTRUMENTS AND AUTOBAR SYSTEMS

← Circle 37 on inquiry card. For further information circle 38 on inquiry card.

SCIENCE NEWS FOR YOUR HEAT-TREAT

For the first time, plant metallurgists can control carburizing by direct measurement of carbon in hot furnace gases.

Scientists have long known that the electrical resistance of a piece of steel will change whenever there's a change in the carbon content of the metal. This basic fact is now being put to work by many progressive metallurgists and heat-treaters. For L&N has applied the principle in a brand-new Primary Element called a Carbohm. In use, a Carbohm projects into the heat-treating furnace . . . looks rather like a thermocouple. Whenever the amount of active carbon in the furnace gas begins to increase or decrease, the Carbohm detects the change. An automatic controller connected to the Carbohm throttles the carbon supply up or down, to keep the furnace gas at desired strength. And a Micromax Recorder plots the result . . . as easy to read as a record of temperature.

The complete equipment—Carbohm, Controller and Recorder—is called Microcarb Control. Because the furnace and its temperature control must be designed to meet the needs of atmosphere regulation, Microcarb can be used only with the Series H Homocarb Furnace. It's our opinion—based on 35 years' experience in making fine heat-treating equipment—that any heat-treating department can do better work with Microcarb than by any other known means. And, because Microcarb adds another automatic control to the carburizing process, it should enable your plant to cut the costs of any carburized, mass-produced part or parts.

To top management, Microcarb means better competitive position for the individual company.

To production executives, Microcarb means closer following of production schedules, because carburizing speeds and results are definitely more predictable than ever before.

To personnel executives, Microcarb means cleaner, more attractive working conditions. And, if the heat-treat uses incentive pay, Microcarb helps heat-treaters increase their earnings, because it makes it easier for them to apply their skill and therefore increase their productivity.

To metallurgists, Microcarb means some or all of the above advantages, plus a tightening of technique such as every technician likes. "New" or hard-to-handle steels hold fewer puzzles. Standard steels emerge with closer specifications. The heat-treat takes another long step toward becoming a manufacturing laboratory.

Let us send you further facts about this new Microcarb Control. Just Check the coupon:

LEEDS & NORTHRUP CO.
4955 Stenton Ave., Phila. 44, Pa.

Please send Catalog T-623; Microcarb Control & Homocarb Furnaces

Please send Sec. 4 of Catalog T-623; Microcarb Control only

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LEEDS & NORTHRUP CO.

Electrical Measuring Instruments **Automatic Controls**
Heat-Treating Furnaces

Jrl Ad TD4-623(5)

For further information circle **39** on inquiry card.

EDITORIAL

The Michigan-State Instrumentation Conference

REGISTRATION by 200 men from colleges and industrial concerns at the Instrumentation Conference held at Michigan State College on March 19-20 typifies the great interest in the objectives of the conference, which were stated as follows:

1. To relate the role and needs of instrumentation in production and research to college interests and responsibilities.

2. To suggest specific activities the colleges might undertake.

3. To suggest specific ways by which industry might assist the colleges in these activities.

The attendance comprised about seventy educators from colleges all over the country, about 65 industrial users of instruments, and about 65 representatives of instrument manufacturers—most of whom are recognized authorities in their fields of endeavor. R. J. Jeffries of Michigan State did an outstanding job in making it possible for this important group to assemble.

This report of the meeting (*Instruments* was the only technical magazine covering this important meeting) will first give the important points brought out by each speaker.

The first speaker was W. Wildhack of the National Bureau of Science, whose subject was "What is Instrumentation?" Wildhack defined an instrument as a device for extending or refining the sensory, communicative, or perceptual faculties of man. The functions of an instrument can be one or more of the following: detection, transmission, amplification, signal transformation or conversion, indication, recording, and control.

The second speaker, J. D. Trimmer, University of Tennessee, spoke on "The Challenge of Instrumentation as a Science." A distinction between the two basic instrument functions—measurement and control—was attempted in terms of the distinction between words and deeds, and this abstraction was extended to include the possible entropy change associated with a measurement or a control action. He asserted that there still was a need for a taxonomy (systematic classification) of instruments.

The third speaker, G. M. Rassweiler of General Motors, spoke on "Meeting Instrumentation Needs of the Industrial Research Laboratory." He took the conferees on a pictorial tour of the Physics-Instrumentation Laboratories of General Motors. He made the important point that his company needs men of various training and abilities in instrumentation. Specifically, men are needed for (1) using instruments in conventional manner in the laboratories, (2) designing new instruments when commercial ones are not available, and (3) applying instruments in new ways and thus opening new fields of endeavor. Men with inventive minds (a rarity) are needed for the second type of work; men with imagination and a practical sense (also rare) are needed for the third type of work.

The fourth speaker, J. B. MacMahon of Republic Flow Meters Corp., then spoke on "Meeting Instrumentation Needs of the Process Industries." He brought out that many variables—paper quality, human comfort, etc.—are not yet measurable, that the behavior of processes during transient disturbances must be better known, that mathematical analyses of process operation have not been completely successful, and that you can't build judgment into a machine.

George Muschamp, of the Brown Instruments Division of Minneapolis-Honeywell Regulator Co., then spoke on "Needs of the Instrument Manufacturing Industries." His major points included: (1) Capital expenditures for instruments by industry are not cut as much as other capital expenditures. (2) The initiative for starting research and developmental programs—such as computer programs—rests with the schools. (3) The instrument manufacturers need research, design, and feedback engineers; specialty men are needed. (4) Practical application engineers are more important than is realized; the application engineer is the key figure in putting instruments to work. (5) Educational emphasis should be on fundamentals. (6) Graduate courses in instrumentation are needed.

R. T. Sheen, Milton Roy Co., spoke on the "Educational Activities of the ISA." He reviewed the recommended practices, maintenance clinics, annual exhibit and conference, local meetings and symposia, instrument-course outline, and other activities of the ISA.

Paul Klopsteg of the National Science Foundation, speaking on "Instruments and Research," then brought out that an instrumentology center or laboratory should be established in the university. He outlined the functions, advantages, and services that can be rendered by such a group.

R. W. Jones of Northwestern University then spoke on "Instrumentation and the Philosophy of Engineering Education." He brought out that instrumentation is changing the perspective and testing the adequacy of engineering curricula.

The final session was devoted to instrumentation activities at various universities. H. C. Roberts of the University of Illinois said that his university has no instrument courses per se, but has an instrument center to serve all projects and departments with repair, acceptance tests, instrument loan, instrument design, etc. C. S. Draper of the Massachusetts Institute of Technology then outlined the extensive instrument activities in the Aeronautical Engineering Department of MIT. He pointed out that one undergraduate course in measurement and control is required of all seniors in the Aeronautical Engineering Department, that there are 19 graduate study courses, that a doctor's degree is given in instrumentation, and that the instrument laboratory has 500-600 regular employees, not including staff and student members. D. P. Eckman then told of the instrumentation activities at Case Institute of Technology. The final talk, by R. J. Jeffries, covered the activities at Michigan State.

Impressions

A brief listing of the major points made by speakers and discussors includes: (1) "Something more" is needed on instrumentation in college curricula; (2) there is neither time nor money available for more specialized undergraduate courses; (3) the colleges would like the instrument industry to support more activities on instrumentation at the colleges—and the instrument industry thinks that the initiative rests with the colleges; and (4) most universities are using the instrument center—a service and supply center—to aid all departments in the university with instrument problems.

The most practical aspect of the conference was the outline of activities at the various colleges—which ranged from an instrument lab to a Ph.D. in instrumentation. These résumés could be of value to the educators at the meeting who wish to institute some instrumentation activity.

The various talks emphasized that educators and universities are recognizing the growing importance of instrumentation—but little was proposed in concrete terms. There was too much talk of instrumentation—and too little about instruments. There was no recognition of the fact that instruments are tools, not just equations, theories, principles, and generalities! Certainly much of the time devoted to glowing accounts of the importance of instrumentation was wasted. Nor was there recognition of past work or accomplishments—M. F. Béhar established the basic taxonomy many years ago.

There was too much emphasis on "generalized instrumentation education." Different types of instrument men need

Continued on page 760

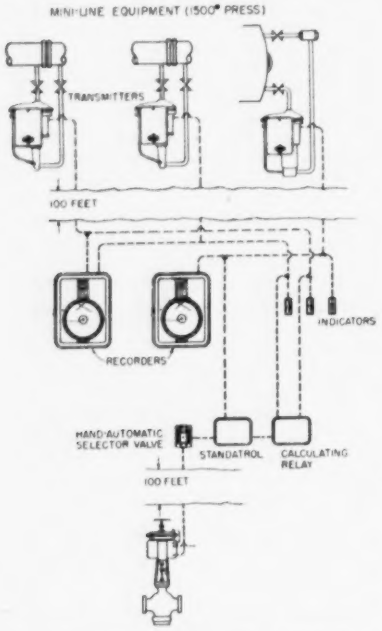
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, computing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 785

Industrial Automatic Control Systems

New "Mini-Line System," for process plants as well as power plants and public utilities, comprises some of



maker's present components and six new types of components: (1) multipoint indicator, (2) pneumatic transmitter, (3) pneumatic recorder, (4) ratio relay, (5) remote manual loader, (6) selector valve. Diagram shows some of these new components in one arrangement (for automatic feedwater control). Value of each measured variable is transmitted to control center by one low-pressure air line instead of two high-pressure instrument lines of larger size. All adjustments are incorporated in relays and selector valves. Maker supplies instruments and control panels, desks, etc., ready for plug-in, saving weeks or months of construction time.—*Bailey Meter Co.*, 1041 *Ivanhoe Rd., Cleveland* 10, *Ohio.*

For further information circle 201 on inquiry card.

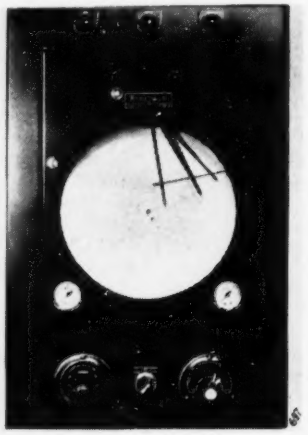
3-D Movie Screen

New "Magniglow Astrolite" projection screen for third-dimensional motion pictures, said to guarantee "perfect vision from any seat in the house," is a laminated sandwich of Monsanto "Ultron" vinyl and "Vuepak" acetate.—*Glowmeter Corp., Buffalo, N. Y.*

For further information circle 202 on inquiry card.

Program Controller

New automatic controller, especially adapted for cascade control systems and for program control, has a motor-driven index or setting-arm. It con-

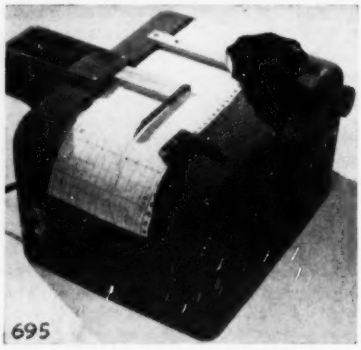


sists of a thermometer controller plus an index-setting mechanism that includes a reversible motor, a gear train, and two cam-actuated "Micro" limit switches. This type of controller is particularly useful where programs must be varied from batch to batch, as in textile industry.—*Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia* 44, *Pa.*

For further information circle 203 on inquiry card.

Square-root Planimeter

New planimeter, for flow chart totalizing of 3-in. miniature (graphic panel) strip-chart recorders, provides true square root extraction and in-

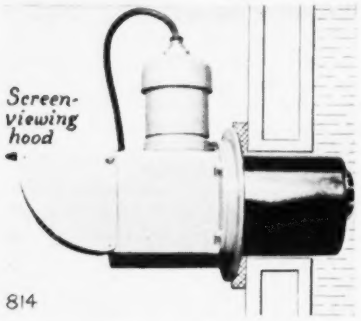


tegration without approximation over entire range of flow-rate. Totalizing is accommodated from leading to trailing edge of chart. Weight 10 lbs.—*Librascope, Inc.*, 1607 *Flower St., Glendale* 1, *Calif.*

For further information circle 204 on inquiry card.

Continuous Direct-reading Refractometer

New "OPL" (French-made) industrial refractometer permits continuously observing variations in refractive index of a liquid being processed;

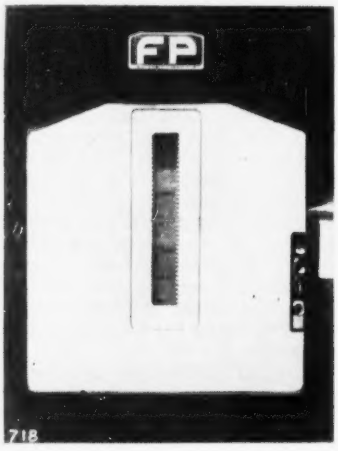


can be read accurately by unskilled personnel; utilizes reflection from interface of prism immersed in processed liquid. Optics housing is of Inox alloy to avoid vitamin-oxidation and other undesired effects. Models are available for concentrations of 0-45, 35-75 and 60-90 percent.—*E. J. Van der Leur*, 60 *Beaver St., New York* 4, *N. Y.*

For further information circle 205 on inquiry card.

Moving-scale Indicator

New indicating instrument comprises a moving strip scale behind a fixed horizontal hairline. Parallax is virtually eliminated. On current model, total scale length is 72 in. Indicator can be located up to 2000 feet from primary element (flow-rate, etc.) with no loss in accuracy (greater distances with special alignment). Current model is designed for use with maker's "54-OLX" flowmeter and "Ratotronic"

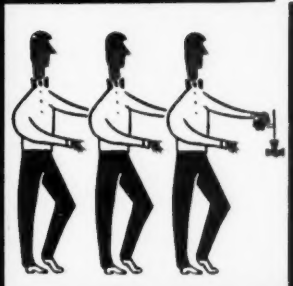


First of a Series

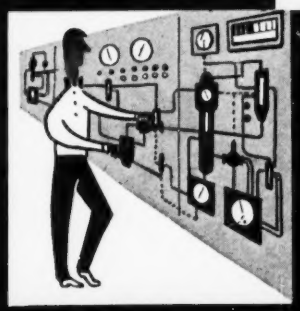
One man can act . . . more quickly and effectively

INDUSTRY has now realized that the completely automatic plant without any operator is generally impractical. Only the human mind can apply the judgment necessary to supplement instrumentation . . . adjust for corrosion . . . and be able to change constantly with advancing technology.

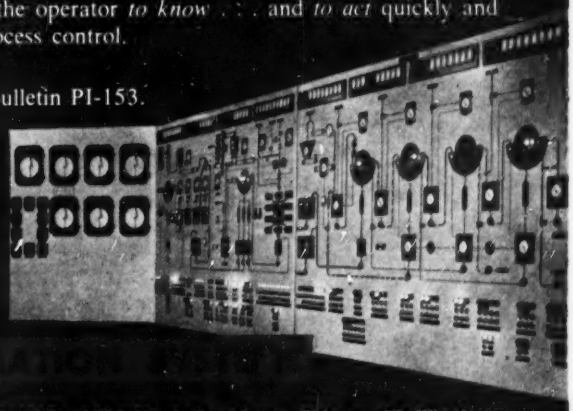
HOWEVER, the advantages of only *one* operator are very important. He can operate with singleness of purpose and co-ordination that no two or more operators could duplicate. BUT, he needs help. He needs information. *This is the basis of the* PANELLIT *business.*

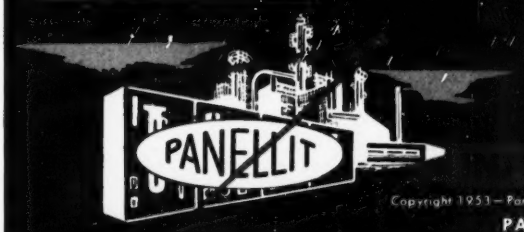


PANELLIT integrates automatic control into an *overall information system.* PANELGRAPHS using graphic symbolism make it possible for the operator to visualize a large mass of instrument data. PANALARM ANNUNCIATORS watch the process . . . allow the operator to concentrate on essentials . . . signal when any "off-normal" condition develops. PANASCAN SCANNING SYSTEMS handle masses of information . . . weed out the unimportant . . . store it up . . . record it or bring it to the operator's attention if "trouble" occurs. All these combine as PANELLIT INFORMATION SYSTEMS . . . enabling the operator *to know* . . . and *to act* quickly and effectively for better process control.



Write for Panelgraph Bulletin PI-153.





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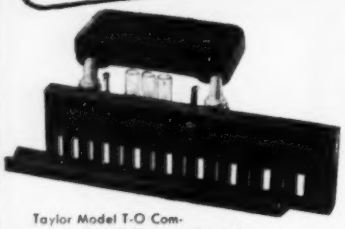
PANELLIT, INC., 6312 North Broadway, Chicago 40, Illinois

For further information circle 40 on inquiry card.

Users say they're

TOPS FOR SPOT pH, CHLORINE TESTS



Taylor Model T-O Comparator for pH. Slides available for pH as low as 0.2 or as high as 13.6. Phosphate slides work on same base. Chlorine comparators also available.

TAYLOR COMPARATORS *with* **GUARANTEED COLOR STANDARDS**

EASY TO USE--

Taylor Comparators use the familiar colorimetric method of comparison . . . but without the need for handling fragile single standards. Each complete set of Taylor Liquid Color Standards in sturdy plastic slide, many slides usable on one base.

FAST TO USE--

many determinations can be made in a matter of seconds, others take no longer than two minutes.

CONVENIENT TO USE--

you can carry the lightweight set to the testing spot, no necessity for carrying solution samples back to the lab.

ACCURATE TO USE--

because all Taylor Liquid Color Standards are unconditionally guaranteed against fading, thus there is no chance of mechanical inaccuracy.

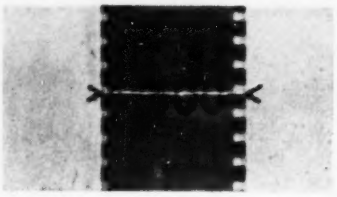
WANT TO KNOW MORE?

See your lab supply dealer for Taylor sets or write direct for free copy of this informative handbook, "Modern pH and Chlorine Control". Describes theory of pH and chlorine control, illustrates full Taylor line.

W. A. TAYLOR AND CO.
416 RODGERS FORGE RD • BALTIMORE, MD.

For further information circle 41 on inquiry card.

NEW INSTRUMENTS

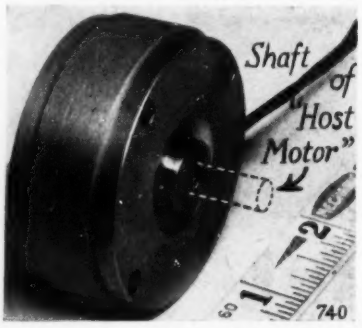


self-balancing inductance-bridge transmission system. Film scale and positioning servomechanism are mounted in a 14 x 18 x 12-in. case, in which up to four scales may be installed, with a circuit-selector switch: selection of any primary circuit automatically illuminates corresponding scale.—*Fischer & Porter Co., 10 Jacksonville Rd., Hatboro, Pa.*

For further information circle 206 on inquiry card.

Synchronous Brake

New Synchronous Brake, first device of its type, makes it possible to rotate a load at a desired synchronous speed without using a synchronous



motor as drive. It is phase-sensitive and eliminates 180-deg. ambiguity. In its simplest application, its stator is mounted on face of "host" motor and its hollow-shaft rotor is fastened on shaft of "host" motor. Synchronous Brake stator is fed desired frequency and, when "host" motor starts and passes through corresponding speed, it is locked in step at that speed.—*Allard Instrument Corp., 30 Broad St., New York 4, N. Y.*

For further information circle 207 on inquiry card.

X-ray Image Intensifier

New "X-ray Image Amplifier" produces images 800 to 1200 times brighter than those obtained with conven-

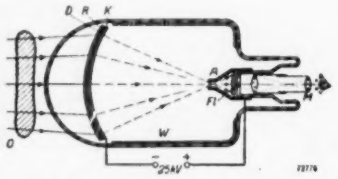


Fig. 1. Diagrammatic cross-section of the image intensifier. *R* = fluoroscopic screen on which the X-rays are received after passing through the object to be examined *O*, and the glass wall of the tube. *D* = support of fluoroscopic screen and photocathode *K*. The fluorescent radiations produced in *R* release electrons from the photocathode *K*. The "electronic image" is reproduced on a reduced scale by the electric field between *K* and the perforated anode *A*, on a viewing screen *F1*; this image is observed through a simple microscope *M*. *W* is a conductive layer on the inside of the tube.

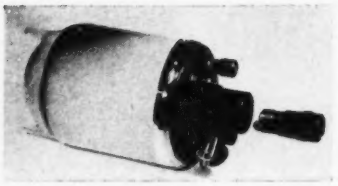


Fig. 2

tional fluoroscope; makes it unnecessary for radiologist to condition his eyes in a dark room for 15 minutes before examinations; minimizes problems of x-ray cinematography.—*North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.*

For further information circle 208 on inquiry card.

Hand Polariscope

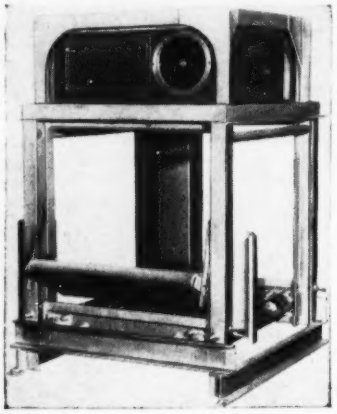
New "Model 242.3" hand polariscope, for use in laboratory and factory for detection of strains in glass

and plastics, and in glass-to-metal seals, has polarizer fixed in one end of frame, analyzer is rotatable through 180 deg. in other end, and 3.25-in. space between for object under examination.—*Pacific Transducer Corp., 11921 W. Pico Blvd., Los Angeles 64, Calif.*

For further information circle 209 on inquiry card.

Automatic Scale

New "Model 200S Checkweight Scale" indicates weight of filled containers and automatically separates

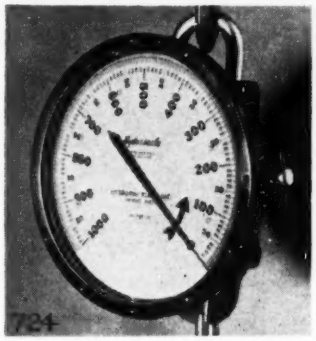


off-weight containers from properly-filled packages. Independently adjustable tolerance settings establish overweight and under-weight limits. Automatic Weight Control mechanism is available for attaching to existing filling scales. Additional optional equipment includes an electrically-operated reset counter to tally packages of various classifications, and a printing recorder.—*Thayer Scale and Engineering Corp., East Water St., Rockland, Mass.*

For further information circle 210 on inquiry card.

Batching Scale

New "Hydroscale" for measuring pour-off has a reverse-reading dial: When a full container is lifted, operator resets dial so that "0" coincides

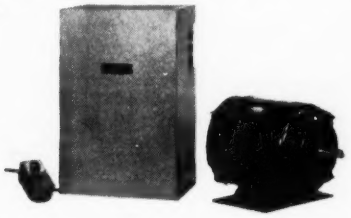


with pointer; as contents are poured off, pointer retreats, directly indicating amount of decreased weight. Available at present in 500- and 1000-lb. models with 12-in. dials.—*Hydroway Scales, Inc.*, 20624 *W.* 8 *Mile Road, Detroit* 19, *Mich.*

For further information circle 211 on inquiry card.

Motor Control Systems

New redesigned line of "Electronic Variable Speed Motor Control Systems," up to and including 3-hp. models, have new cabinet design for wall

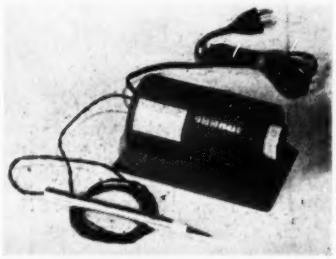


or bench mounting and critical-component plug-in assemblies. New electrical design utilizes motor series field as a torque signal source in feedback circuit to provide constant system torque capability. Controlled acceleration on many models. Fingertip-controlled models for manual speed selection at remote points; "Automatic Servospeed" systems for industrial operations or processes.—*Servospeed Div., Electro-Devices, Inc.*, 4-6 *Godwin Ave., Paterson, N. J.*

For further information circle 212 on inquiry card.

Marking-&-counting Device

New "Mark-N-Count" has a pencil for checking blueprints, lists, etc., and a six-digit counter which clicks aud-



Greater Pumping and Vacuum-Producing Ability

Welch

Two-Stage Duo-Seal® Vacuum Pump

GUARANTEED VACUUM

0.0001 mm Hg. or 0.1 Micron

FREE AIR CAPACITY

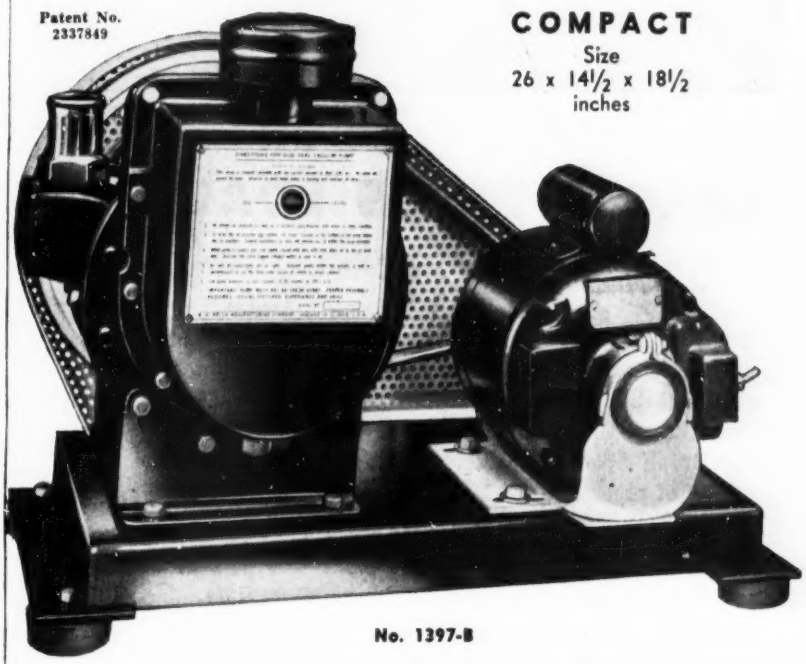
300 Liters Per Minute

152 Liters Per Min. at 1 Micron Pressure

QUIET IN OPERATION

Patent No. 2337849

COMPACT Size 26 x 14½ x 18½ inches



No. 1397-B

1397B. DUO-SEAL PUMP, motor-driven, mounted on cast-iron base with ¾ H. P. 110 volt single-phase motor, with double-groove pulleys, 2 "V" belts, belt tightening device, six feet of connecting cord, snap switch and attachment plug.

COMPLETE $515.00

TIME REQUIRED TO EVACUATE INDICATED VOLUME TO VARIOUS PRESSURES

PRESSURE mm of Hg. Microns	EVACUATED VOLUME IN LITERS 5-L		10-L		25-L		50-L		100-L	
	Sec	Min	Sec	Min	Sec	Min	Sec	Min	Sec
10^{0} – 1000	8		17		41	1	23	3	0
10^{-1} – 100	11		23	1	0	2	0	4	12
10^{-2} – 10	16		32	1	24	3	0	6	6
10^{-3} – 1	24		48	2	6	4	16	9	0
10^{-4} – 01	37	1	14	3	9	6	22	13	54

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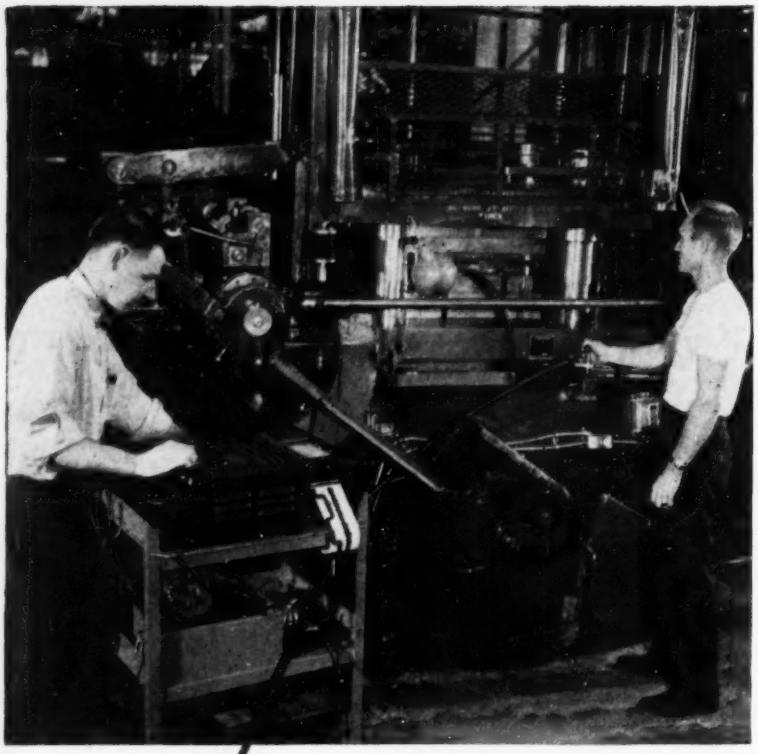
Manufacturers of Scientific Instruments and Laboratory Apparatus

For further information circle 42 on inquiry card.



CHECKS PRESS LOADING
with Brush Recording Analyzer

Here, in the plant of a large manufacturer of automotive parts, periodic checks are made on this 150-ton mechanical press to spot possible overloading. With resistance-type strain gages mounted on the press, the signal is amplified and recorded by the Brush Strain Analyzer... producing an *immediate chart record* of press strain.

Since measurements can be made quickly and easily, the Brush Strain Analyzer furnishes a *practical method* of detecting overloading and avoiding costly breakdowns, and lengthening press life.

You can use Brush Recording Analyzers to save time and solve problems... in measurement of strain, torque, vibration, pressure, d-c or a-c voltages or currents, and other variables. Brush representatives are located throughout the United States. In Canada: A. C. Wickman, Limited, Toronto. For bulletin write Brush Electronics Company, Dept. A-5, 3405 Perkins Avenue, Cleveland 14, Ohio.

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INDUSTRIAL AND RESEARCH INSTRUMENTS
PIEZOELECTRIC MATERIALS • ACOUSTIC DEVICES
MAGNETIC RECORDING EQUIPMENT
ULTRASONIC EQUIPMENT

For further information circle **43** on inquiry card.

ibly each time a mark is made. User is spared mental strain, can discuss work without risk of mistake.—*May Engineering Co., 6055 Lankershim Blvd., North Hollywood, Calif.*

For further information circle **213** on inquiry card.

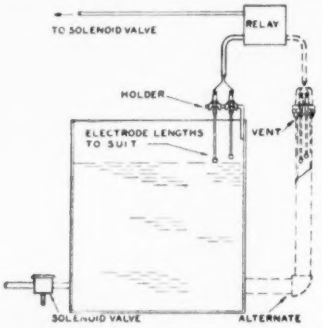
Two-speed Chart Drive

New two-speed chart drive instantly increases chart drive speed 30 or 60 times when a variable exceeds predetermined limits; is especially applicable for control-point adjustment during start-up or when an upset occurs in controlled process; is designed for use in maker's single-record strip-chart instruments, and for conversion of single-speed instruments in use. —*Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

For further information circle **214** on inquiry card.

Liquid-level Controller

New "Johnson Tank Controls," for controlling levels in tanks, vats, etc., comprise electrode holder, relay, and

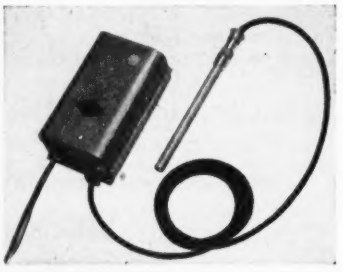


direct-operated solenoid valve. Two stationary electrodes are suspended in tank. Valve may be installed in either supply or discharge line. Components are available in several sizes. —*Johnson Corp., Three Rivers, Mich.*

For further information circle **215** on inquiry card.

Liquid Level Controller

New "Belmont Level Control" is based on capacitive action of liquid surrounding a porcelain-enamel-cov-

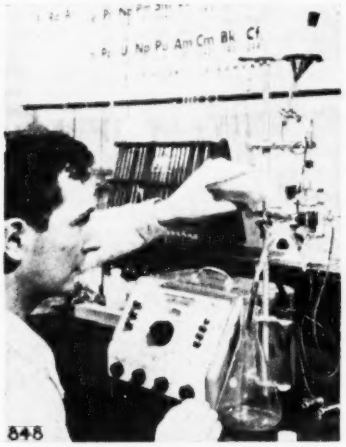


ered electrode. Connecting cable can be up to 1000 feet long. Two main controls (liquid level and differential) are designed for screwdriver adjustment; vernier control on liquid level is operated by a panel-front knob. —*Thermo Instruments Co., 1166 El Camino Real, Belmont, Calif.*

For further information circle **216** on inquiry card.

Leaded-gasoline Tester

New "TEL-Meter," utilizing polarography, gives direct readings of tet-



raethyl lead in gasoline in range of 0-5 ml. per gallon.—*Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.*

For further information circle 217 on inquiry card.

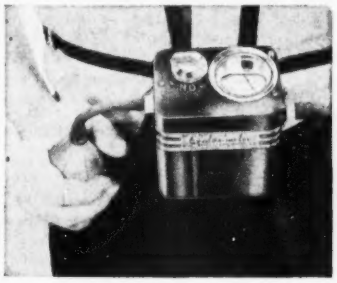
Ultraviolet Photometer for Air-pollution Studies

New ultraviolet photometer for control of atmospheric pollution operates by measuring decrease in intensity of a beam of UV light when contaminated atmosphere passes through a transparent sample cell in optical path; can detect a 0.01-percent decrease in light intensity. New method of calibration overcomes adsorption problem through use of a gas-mixing apparatus whereby samples of air containing known low concentrations of gases are prepared continuously. —*E. I. duPont de Nemours & Co., Wilmington 98, Del.*

For further information circle 218 on inquiry card.

Leaded-gasoline Vapor Concentration Indicator

New "Model 5 MSA Explosimeter," for men working with or handling leaded gasoline, has detector filaments

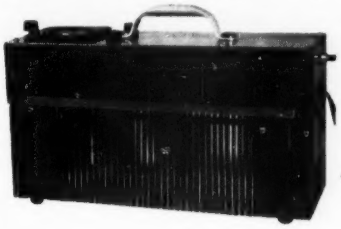


operated at sufficiently high temperature to prevent lead-deposit contamination; is listed by Underwriters Laboratories.—*Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh 8, Pa.*

For further information circle 219 on inquiry card.

Mercury-vapor Meters

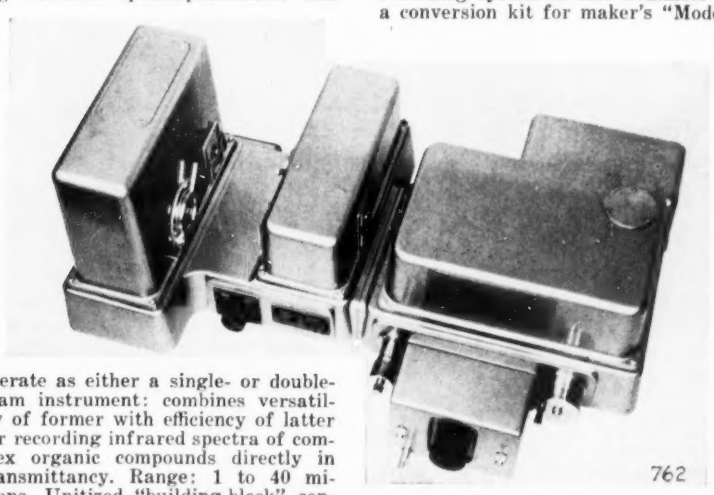
New mercury vapor meters are available in four models all featuring high sensitivity and simplified oper-



ation. Standard model weighs 7 lbs. and has a range of 0.005 to 0.1 milligram per cubic meter. Operation: after setting zero and sensitivity

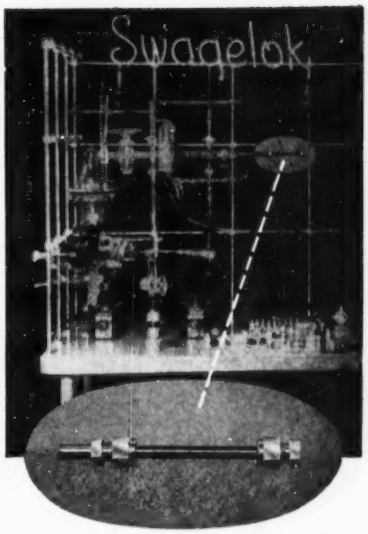
Infrared Spectrophotometer

New "Model 13" direct ratio-recording infrared spectrophotometer can



operate as either a single- or double-beam instrument: combines versatility of former with efficiency of latter for recording infrared spectra of complex organic compounds directly in transmittancy. Range: 1 to 40 microns. Unitized "building-block" construction permits use of microscopes, reflectance attachments and accessories for ultraviolet and visible recording. Savitzky-Halford double-beam recording system is also available as a conversion kit for maker's "Models 12 and 112" infrared spectrometers. —*Perkin-Elmer Corp., Norwalk, Conn.*

For further information circle 220 on inquiry card.



0.0000000194 PSIA

STANDARD

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TUBE FITTINGS HOLD ULTRA-HIGH VACUUMS

Swagelok tube fittings, by providing a vacuum-tight mechanical seal, have now extended ultra-high vacuums beyond the laboratory into industrial applications. The Swagelok Ultra-High Vacuum Demonstrator above incorporates standard Swagelok fittings—a reducer and a cap. It demonstrates that the air pressure in the system can be reduced repeatedly from the normal 14.7 pounds per square inch absolute to 0.0000000194 psia. For information on Swagelok fittings and ultra-high vacuum test data address Dept. 152.

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SWAGELOK FITTINGS AVAILABLE IN: BRASS, ALUMINUM, STEEL, STAINLESS STEEL, MONEL

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HUMPHREY LINEAR POTENTIOMETER

Resistance values to 13,000 ohms/inch ...higher in special units

½" Diam. for strokes up to 3"
¾" Diam. for strokes over 3"
Dual element construction

NOW FOR THE FIRST TIME...a rugged Potentiometer that will give long, noise-free performance when subjected to vibration, dither and other environmental conditions.

Absolute precision linearity with clear, sharp signal, because the Humphrey unit is exclusive in internal design. It is fully tested and has been qualified for use in many military applications. Humphrey design service is available to meet your special requirements.

Also available are Humphrey Rate and Free Gyros and Accelerometers. Special Potentiometers Custom-built.

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25 Stillman Street, San Francisco 7, California
1915 1st Avenue, South, Seattle 4, Washington

For further information circle 45 on inquiry card.

NEW INSTRUMENTS

knobs, instrument is held in atmosphere to be tested and the mercury vapor concentration is read directly. For situations requiring less sensitivity there is a low cost model with a range of 0.05 to 10 mg. per cu. m.; another model features an adjustable alarm.—*Harold Kruger Instruments, P. O. Box 164, San Gabriel, Calif.*

For further information circle 221 on inquiry card.

Combustion Analyzer

New "Model 140C" all-electric combustion analyzer measures CO_2 (0-20 percent), temperature (100-1000 F.)

and draft (0-0.3 in. water): is powered by a dry cell battery; has glass-coated thermistor; gas analysis cell with built-in temperature compensator; filter-drier; compensated thermocouple lead; and two 30-in. probes (longer probes available).—*Victory Engineering Corp., Springfield Rd., Union, N. J.*

For further information circle 222 on inquiry card.

Six-channel Oscillograph

New "Model BL-226" portable six-channel oscillograph is equipped with six "Model BL-902A Penmotors" which permit the simultaneous re-

cording in frequency range of d.c. to 100 cps. A large window permits viewing chart. Controls provide starting, stopping and selection of chart speeds 5, 25, and 125 mm. per second. A remote control box (accessory) permits operator to start and stop chart drive from remote locations.—*Equipment Div. 97H, Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.*

For further information circle 223 on inquiry card.

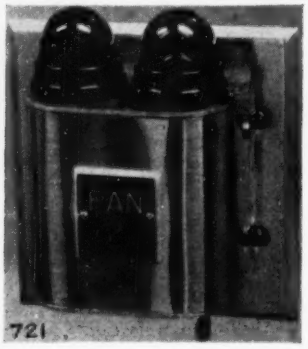
Industrial TV Components

New package of five electronic components designed to complement "RCA-6198 Vidicon" industrial TV camera tube includes a deflecting yoke (216D1), focusing coil (217D1), alignment coil (218D1), horizontal-deflection-output transformer (233T1), and vertical-deflection-output transformer (234T1).—*Tube Dep't, RCA Victor Div., Radio Corporation of America, Camden, N. J.*

For further information circle 224 on inquiry card.

Alarm System

New "Model A Vigilarm" is a completely wired unit which needs only connection to trouble contacts, audible signal and power. An abnormal con-

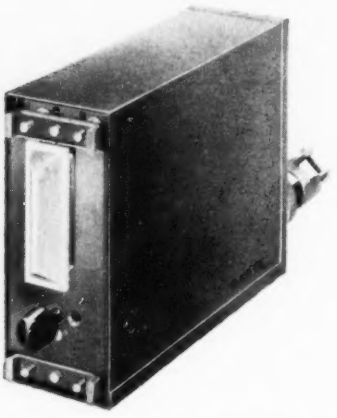


dition lights both red and green lamps and sounds audible signal. Operation of toggle switch silences audible signal and extinguishes green lamp, leaving red lamp on. When contacts restore to normal, audible signal sounds again, red lamp goes out and green lamp lights. Operation of toggle switch silences audible signal and extinguishes green lamp, indicating return to normal.—*H. R. Kirkland Co., Morristown, N. J.*

For further information circle 225 on inquiry card.

Signal Alarm Unit

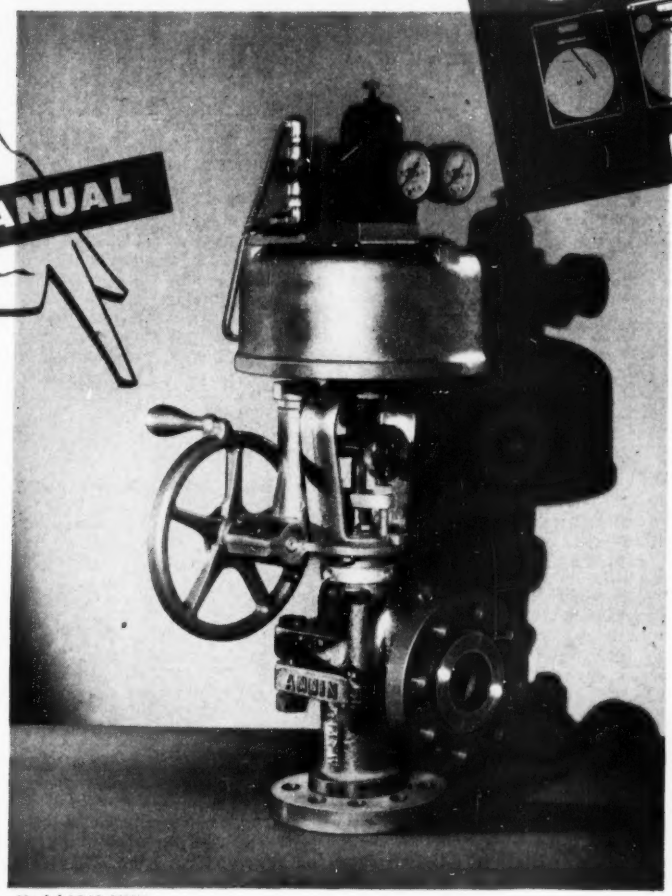
New "Monolarm" signal alarm unit, for flow line and graphic panels, is said to have many advantages for



Class I, Groups C and D, Division 2 operation: Single narrow bezel-and-button fits into line diagram without interrupting continuity; lighting indications in two or three colors on

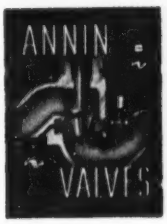
VERSATILITY *plus!*

COMBINATION OF AUTOMATIC-MANUAL OPERATION INCREASES FLEXIBILITY OF ANNIN VALVES...



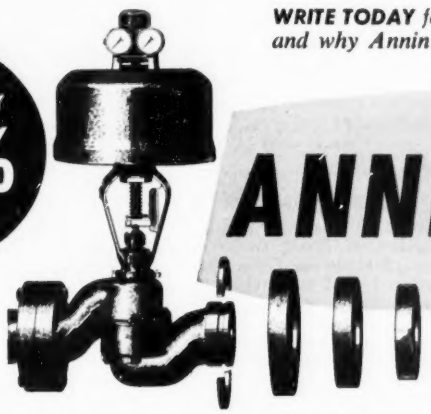
Model 1560 SMW

To ANNIN's powerful Domotor automatic operation add the versatility of a side-mounted Handwheel. This combination provides the answer to field demands for convenient and positive *supplementary* control during start-up periods, or when the system is shut down temporarily for instrument repair. The Handwheel can act to operate the valve manually and provides an adjustable limit stop in either the opening or closing direction. This auxiliary manual control is particularly advantageous in adjusting the minimum or maximum flow of steam to turbines, steam engines and other process equipment. Further evidence of the increased utilization, simplicity of design and greater economy of ANNIN VALVES.



***WRITE TODAY** for illustrated bulletin showing how and why Annin offers the best in control valves.*

CUT INVENTORY **50%** WITH



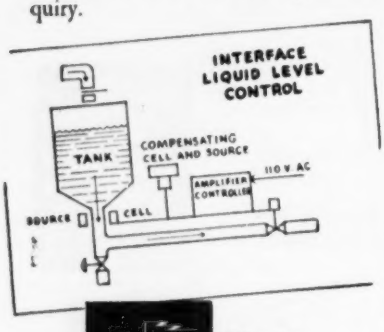
ANNIN *Control* **VALVES**

THE ANNIN COMPANY 3500 Union Pacific Avenue
Los Angeles 23, California

For further information circle 46 on inquiry card.

CORROSIVES no longer a control problem

new Ohmart Density Gauges utilize radioactivity to provide a simple, direct, accurate method of measuring many unsual process variables. Corrosive or erosive elements no longer need force you to depend on the evaluation of *secondary* variables—Ohmart Density Gauges can directly evaluate many variables right where they occur—inside the process equipment! And usually installations can be made without any connections into process piping or vessels. Only small *safe* amounts of radioactive material are used, and Ohmart Cells require NO high voltage power supply. Equipment is sturdy and long lasting, and standard measuring and control instruments are employed. In the diagram below, an installation is shown for determining interface liquid level—just one of the many measurement problems, where density is a function of the desired measurement, that can be solved by Ohmart Density Gauges. Complete information or consultation is available upon inquiry.



Electricity From Radioactivity

the ohmart corp.

2335 FERGUSON ROAD
CINCINNATI 38, OHIO

DALLAS CHICAGO

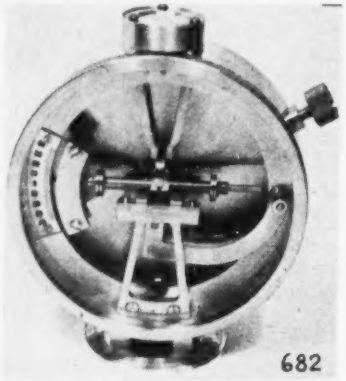
For further information circle **47** on inquiry card.

one bezel; instantaneous connect and disconnect of power supply cable; interlocking plug with hermetically sealed switch makes it impossible to insert or withdraw plug under load; time delay circuit available. Function: when abnormality occurs, normal light ceases to shine, alarm light flashes rapidly on and off, an external howler (if used) is sounded; operator must acknowledge by turning reset switch.—*Russell & Stoll Co., 125 Barclay St., New York 7, N. Y.*

For further information circle **226** on inquiry card.

Prospecting Magnetometer

New "B-2 Magnetometer" is a lightweight (5 lbs. with tripod) direct-reading magnet balance designed primarily for reconnaissance prospecting.

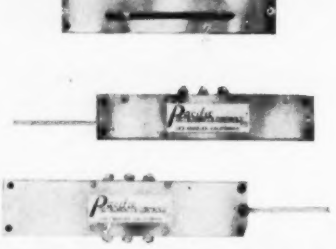


Sensitivity is of order of 40 gamma per division, fairly linear across scale from plus 30 divisions. Among features: latitude and temperature compensation, attached compass and Johnson type levelling head assembly for one-man operation.—*The Radiac Co., Inc., 489 Fifth Ave., New York 17, N. Y.*

For further information circle **227** on inquiry card.

Displacement Pickups

New "PiccOhm Series P1R" linear-motion variable resistors ("potentiometers") are available as single or double units, for side- or end-actua-

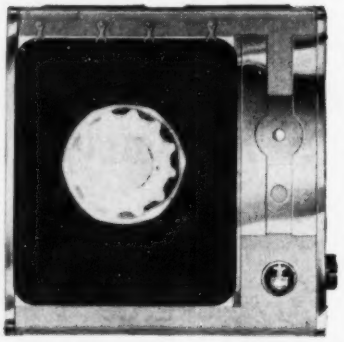


tion, for total displacements from 0.5 in. to 12 in. Normal linearity is 0.5 percent and resolution of 0.001 in. is available. Unique feature is full-length bearing for rod and contact block, with full visibility of working parts when covers are removed.—*Pacific Instruments & Controls Co., 2315 Westwood Blvd., Los Angeles 64, Calif.*

For further information circle **228** on inquiry card.

X-ray Film Viewer

New "High Intensity Illuminator" facilitates x-ray film inspection of industrial parts: radiographs of thickest structures become plainly visible;

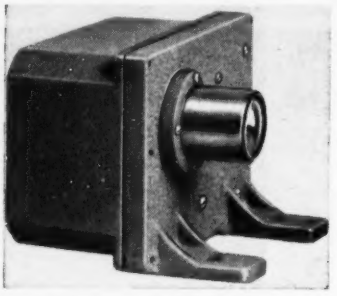


even-light intensity is said to be 20 times greater than that of conventional viewers. Full 14 x 17-in. viewing surface permits inspection of largest films; critical examination of small areas is accomplished before a 3-in. spot of four times over-all intensity.—*Keleket X-ray Corp., 262 W. Fourth St., Covington, Ky.*

For further information circle **229** on inquiry card.

Photoelectric Light Source with Dual-filament Lamp

New "L4" photoelectric light source has a dual-filament lamp. When one filament fails, the other comes on

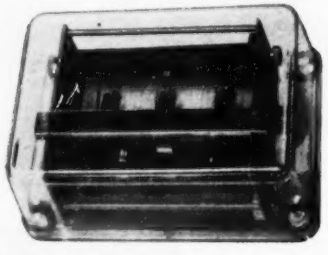


automatically so photoelectric control is not interrupted. Simultaneously, a signal lights up to warn operator.—*The Autotron Company, Box 722-Q, Danville, Ill.*

For further information circle **230** on inquiry card.

Impact Recorder

New "Model HXS" is similar to "Model HX" with addition of a ratchet arrangement to move tape forward

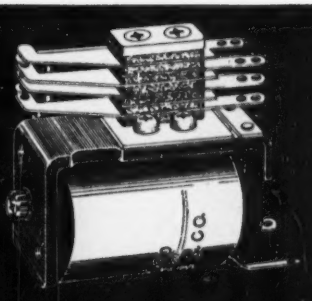


with each shock. It records shocks and impacts from all three directions. Small and lightweight (22 oz.), it

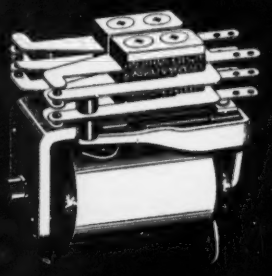
ONE OF THESE 4 CLARE RELAYS will meet most exacting small-space requirements

CLARE TYPE K RELAY

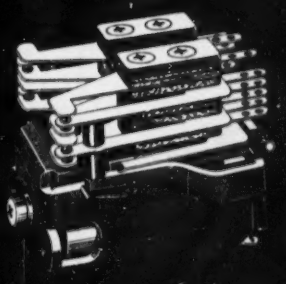
First small size, lightweight telephone type relay. Famous for operating speed and resistance to vibration.



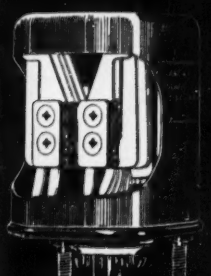
TYPE KX—Adds greater operating range and sensitivity with slightly longer coil.



TYPE R—Adds 120% greater sensitivity and 200% greater operating range than Type K.



TYPE N—Operates on less than 50 milliwatts with 10,000 Ohm coil, 1 form C contact and standard adjustment.



HERMETICALLY SEALED RELAYS

Type N Relay hermetically sealed in steeled container... a feature available with all Clare relays.

CLARE pioneered the small-relay field with the Type K relay. Since that time it has been the mainstay of design engineers who must have a superior relay to operate in extremely small space.

The Clare Type K not only has the advantages of small size and light weight but it is capable of exceedingly fast operation, gives adequate contact pressure and is highly resistant to shock and vibration. Its long life and all-around dependability have enabled this relay to meet many complex engineering requirements.

In order to meet customers' specifications which the Type K would not quite fill, Clare engineers have developed three other small, light weight relays. All retain the basic operating and physical characteristics of the Type K. Two of them, the Type KX and the Type R, have the famous Clare reed armature suspension of special alloy. This has long been recognized as one of the subtler reasons for the superior performance of the Clare Type K relay.

The Type KX adds greater operating range and sensitivity by use of a slightly longer coil which can be safely wound to 8000 ohms resistance. The Type R adds still greater operating range and sensitivity by use of a coil not only longer but of greater diameter. The Type N relay is designed for operation on very low power. It employs a close-coupled magnetic circuit, generous use of magnetic iron and highly efficient coil design. This permits high sensitivity while retaining high contact pressure (minimum 30 grams) and adequate contact gap (minimum 0.0015").

All these relays are available enclosed in hermetically sealed gas-filled containers which increase their life, reliability and usefulness under extreme conditions of altitude, temperature, moisture, fungi, dust and dirt.

Clare sales engineers are located near you. For complete information call the nearest Clare office or contact: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address: CLARELAY.

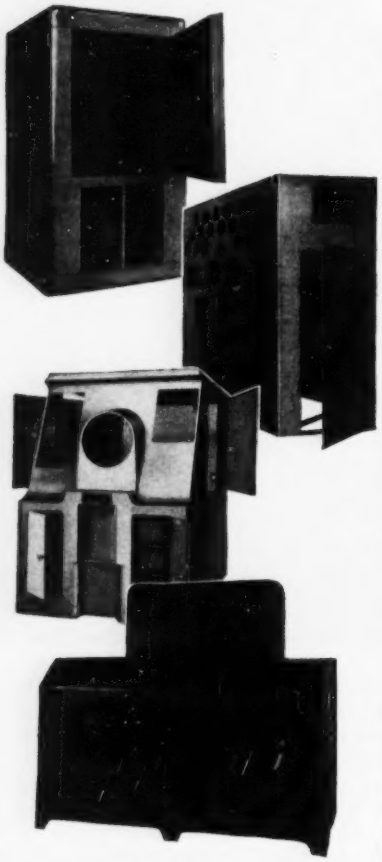
***FIRST* IN THE INDUSTRIAL FIELD**

CLARE RELAYS

For further information circle 48 on inquiry card.

OUR FIRST GOAL IN FABRICATING INSTRUMENT MOUNTING STRUCTURES

Artisans and engineers at Littleford understand and meet exacting requirements of manufacturers of electrical and hydraulic control equipment. Hence Littleford has become a foremost builder of such cabinets, panels, control boards, steel cubicles, mechanism boxes. Get structures right—get Littleford!



FABRICATORS OF PLATE AND SHEET METALS

LITTLEFORD

LITTLEFORD BROS., INC.
424 E. Pearl St., Cincinnati 2, Ohio

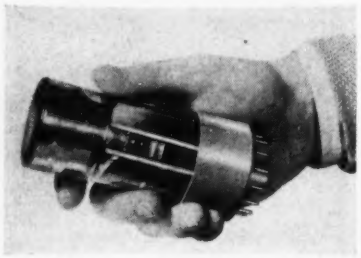
For further information circle **49** on inquiry card.

has applications where time element is not important: drop tests, incline impact tests, etc.—*Impact-O-Graph Corp., 1900 Euclid Ave., Cleveland 15, Ohio.*

For further information circle **231** on inquiry card.

Multiplier Phototubes

New 10-stage multiplier phototubes represent an entirely new design; are of end-window type with spectral-



response peak in the visible region. Average photocathode sensitivity 60 ua/lumen. Optimum photoelectron collection (whence excellent signal-to-noise ratio at low light levels) is accomplished by adjusting potential between shield and photocathode by individual exterior connections. Potentials as high as 190 volts per stage may be applied; 125 to 150 volts recommended.—*Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Ave., Clifton, N. J.*

For further information circle **232** on inquiry card.

Steel Tape

New 25-, 50-, 75- and 100-foot premium steel tapes are said to be "approximately half the price previously

charged for tapes of corresponding quality." Tape is 0.375-in.-wide high-carbon steel, hardened, tempered, Bonderized, enameled in white and numbered in black.—*Evans & Co., Elizabeth, N. J.*

For further information circle **233** on inquiry card.

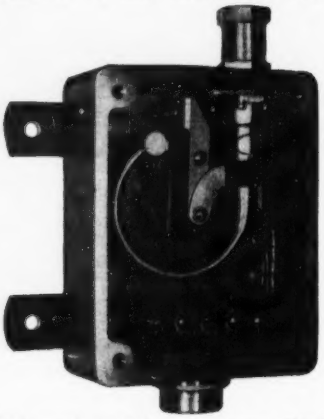
Subminiature Gyroscope

New "Model 7" subminiature rate gyroscope weighs 3 oz. Small mass of its components makes it unusually insensitive to shock and vibration. It is hermetically sealed, for use in aircraft, guided missiles, radar antenna stabilization, etc. Rotor spins at 24,000 rpm. on 6.3 volts at 400 cps. Output 14 millivolts per degree per second input; maximum at 420 degrees per second; minimum resolution better than 0.05 degree per second. Unit resonates at 85 cps. with a 0.5 damping factor. Design readily modified for other voltages, frequencies, and input rates.—*Sanders Associates Inc., 137 Canal St., Nashua, N. H.*

For further information circle **234** on inquiry card.

Pressure Switches

New "Meletron Model 314" pressure switches come in six classes of proof pressures: to 500, 1500, 3,000, 4,500,



6,000, and 12,000 psi.; sense liquid or gas system pressures over an adjustable range of 15 to 10,000 psi.; are available with external adjustment. Variable actuation value ranges from 10 to 2,000 psi. depending on switch class. Actuation may be on increasing or decreasing pressure, automatically reset by snap action.—*Barksdale Valves, 1566 E. Slauson Ave., Los Angeles 11, Calif.*

For further information circle **235** on inquiry card.

Pressure Switch

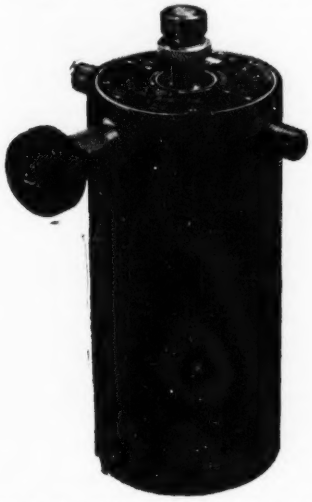
New pressure switch is suitable for water, air or hydraulic pressures; has Bourdon tube element, high and

low pressure limits independently adjustable to any range within 100 psi., including fractions of an ounce. For pressures over 100 psi. an interchangeable unit can be installed with a single screw. Snap-action contact unit has a life expectancy of 1,500,000 operations. Rating 0.5 hp. at 110 v. ac. Weight 12 oz.—*Simple Mfg. Corp., 214 Temple St., Syracuse, N. Y.*

For further information circle **236** on inquiry card.

Pressure Controller

New "No. 8 Cartesian Manostat," for pressure control in laboratory, pilot plant and industry, replaces



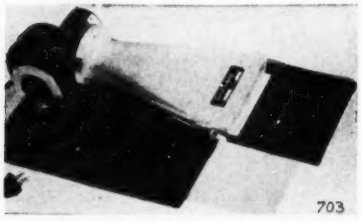
"No. 5 Cartesian Manostat," is simplified: has only to be placed in system and set.—*The Emil Greiner Co., 20-26 N. Moore St., New York 13, N. Y.*

For further information circle **237** on inquiry card.

TEMPERATURE

Thermal Radiometers

New "Model 188 Hemispherical Radiometer," for total-hemispherical or net-exchange radiant-heat measurements by direct electrical means,



comprises a thermopile heat-flow meter 4.5 in. square mounted adjacent to a slotted orifice attached to discharge of a small air blower which eliminates convection effects. For use as a total-hemispherical radiometer ("188-1"), a double shield is provided below primary element. For net-exchange measurements ("188-2"), both upper and lower surfaces of primary element are blackened uniformly. Transient response: 95 percent in 12 seconds.—*Beckman & Whitley, Inc., 930 San Carlos Ave., San Carlos, Calif.*

For further information circle **238** on inquiry card.

Temperature Controller

New "Thermo Electronic Pyrometer Controller" automatically controls temperature of batch processes or equipment suitable for two-position control action; is for use with iron constantan, chromel alumel, or platinum platinum-rhodium thermocou-

$375.00

MODEL 305 **INVERTER - AMPLIFIER**

THE ALLEGANY INSTRUMENT COMPANY, INCORPORATED
1000 OLDTOWN ROAD CUMBERLAND, MARYLAND

For further information circle **50** on inquiry card.

Sound Design
Quality Materials
Precision Workmanship
the superiority of
JERGUSON VALVES
speaks for itself

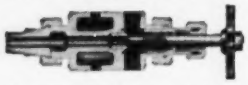
OS&Y Valves for severe conditions

Rugged Jerguson OS&Y Valves are the ideal answer to meet high temperature or corrosive conditions where inside threads can't be tolerated. Efficient outside thread design eliminates possible freezing and allows the valve stem to work freely at all times.

GA Valves for instrument piping and general use

Tremendous time and cost savings are possible with Jerguson GA Valves. Threaded connections can be reduced from 10 to 3 . . . unions, nipples, reducers, elbows, tees, valve, and bleed valve are combined in one space saving unit.

Jacketed Heated-Cooled Valves



Designed especially for use with heated or cooled gages, Jerguson No. 93 Valves have a surrounding jacket for circulating the heating or cooling medium. They give safe, dependable, leak-tight service.

Globe Valves

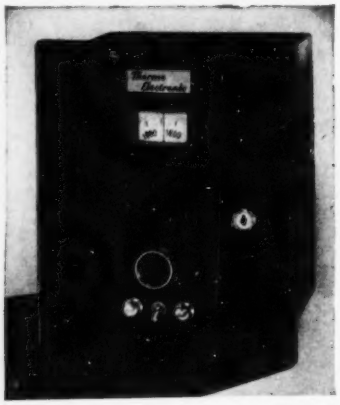
Jerguson Globe Valves, furnished in ¼, ½, and ¾ inch sizes with renewable, regrindable seats. Can be furnished with Stellited stem and/or OS&Y.

All valves shown rated at 3000 lbs. @ 500°F. Send for detailed Data Units . . . or outline your requirements and let Jerguson engineers go to work for you.

JERGUSON
Gages and Valves for the Observation of Liquids and Levels
JERGUSON GAGE & VALVE COMPANY
100 Fellsway, Somerville 45, Mass.
Offices in Major Cities
Jerguson Truss Gage & Valve Co., Ltd., London, Eng.
= Pétrole Service, Paris, France

For further information circle **51** on inquiry card.

NEW INSTRUMENTS

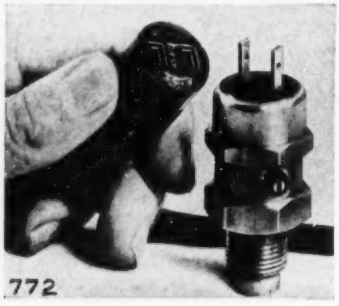


ples; is available in twelve standard scale ranges for controlling temperatures from 0 to 3000 F.; is said to combine measuring accuracy of a null-balance potentiometer circuit with sensitivity and speed of an electronic control system.—*Thermo Electric Co., Inc., Fair Lawn, N. J.*

For further information circle **239** on inquiry card.

Thermal Limit Switch

New "Eco Thermal Switch" has bimetallic actuator; may be set to function at temperatures up to 300 F.;



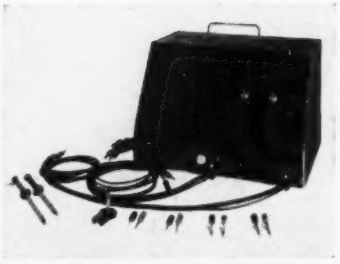
screws into ⅜-inch threaded hole in equipment to be protected such as pump, motor, home heater, etc.—*Eco Engineering Co., 12 New York Ave., Newark 1, N. J.*

For further information circle **240** on inquiry card.

TIME

Time-interval Meter

New "Syncrograph" electronic interval timer for measuring short time intervals (operation of relays, voltage or current changes in circuits, etc.), has three ranges: 0-99.9, 0-999, 0-9990 milliseconds. Indications are displayed as three-digit numbers, with provision for accumulating total of a series. Interval timing may be started and stopped by the following types of input signals, applied in sequence across START and STOP terminals: (1) make, (2) break, (3) positive pulse, (4) negative pulse. When pos. or neg. pulse inputs are used, a four-position switch provides selection of sensitivity levels of 5, 15, 50 or 150 volts to permit rejection of lower-level signals (line noise, etc.). Start

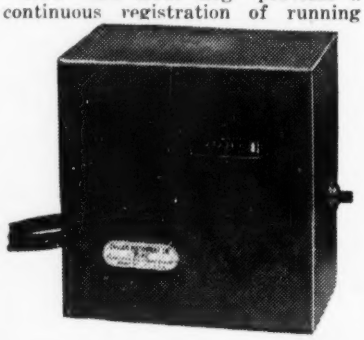


and stop input channels are independent; any combination of the four types of start and stop signals may be used. No external power supply or switching unit is required. Built-in test terminals and switches are provided so that for many applications it is not necessary to arrange external test circuits. Instrument may also be used to count externally-generated pulses: maximum counting rate, 10,000 per second.—*General Railway Signal Co., P. O. Box 600, Rochester 2, N. Y.*

For further information circle **241** on inquiry card.

Elapsed-time Indicator

New "AC Hour Log" provides a continuous registration of running



time for industrial machines operating on a.c.; has interior lighting with off and on switch.—*Engler Instrument Co., 250 Culver Ave., Jersey City, N. J.*

For further information circle **242** on inquiry card.

Elapsed Time Indicator

New "HM2ET" small-size elapsed-time indicator meets standard 2.5-in. JAN dimensional specifications for panel mounting though having a

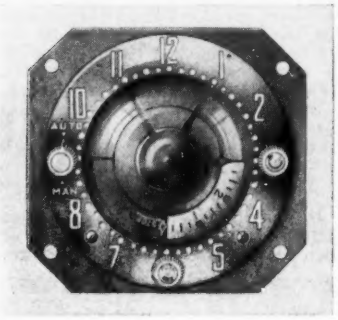
standard size counter. It is hermetically-sealed and absolutely tamperproof. Motor will start readily and operate continuously at temperatures ranging from −55 C. to 85 C. Units are available registering 1/10 hour

steps to 9999.9 or hour steps to 99999; 110-125 or 220-250 volt; 50 or 60 cycle.—*Marion Electrical Instrument Co., Manchester N. H.*

For further information circle 243 on inquiry card.

Range Timer

New Range Timer is said to be unique in having an "erasing dial" that gives at all times a clear and



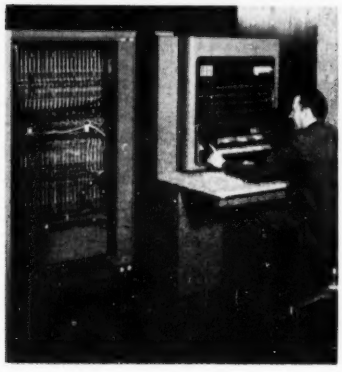
exact indication of time left before completion of cooking.—*Haydon Mfg. Co., Inc., Torrington, Conn.*

For further information circle 244 on inquiry card.

COMPUTING

Electronic Computer

New "701 Electronic Data Processing Machine" is said to be "the first large-scale computer to be produced



in quantity." Illustration shows control center, termed "Electronic Analytical Control Unit," where operator can, when required, change the course of a problem. (Computing and control section at left is shown open.) Indicator lights on panel enable operator to determine phase of work being processed, to observe what number is stored in any location of electrostatic storage unit, etc.—*International Business Machine Corp., 590 Madison Ave., New York 22, N. Y.*

For further information circle 245 on inquiry card.

Plug-in Resistance Decades

New plug-in decade resistance units, primarily designed for setting values on "L3 GEDA" analog computer, are available in two types, with maximum resistance values of 1 and 10 megohms respectively. Each unit has three dials showing set resistance value to with-

To telemeter changes, Specify the new...

Bendix-Pacific RESISTANCE BRIDGE OSCILLATOR TOR-6

The new Bendix-Pacific TOR-6 Oscillator gives improved performance with resistance type strain gages and variable resistance type temperature pickups. The unit operates with unusual stability under extreme conditions of environment.

Unbalance of the resistance bridge provides a voltage which is used to change the frequency of the oscillator. The magnitude and direction of the frequency change is proportional to the magnitude and phase of the bridge output.

SPECIFICATIONS

Bridge Impedance: 120 ohm*
Sensitivity: ±7.5% change of f_o for 0.125% change in resistance in each of four active arms*. (This is RDB specified subcarrier bandwidth)
Frequency Response: Flat within ±2.0% from DC to 10% of bandwidth.
Linearity: Within 1.0% of best straight line.
Stability: Drift less than 0.5% of bandwidth (0.07% of f_o) for 8 hours at 25° C. after 15 minute warmup.
Temperature Effect: f_o changes less than 0.08% of bandwidth per degree centigrade.
Vibration Effect: 1.0% maximum noise at 10 g, 20 to 1000 cps.
Supply Voltage Effect:
Plate Supply: Drift does not exceed 1.0% of bandwidth for ±10% change of plate supply voltage.
Heater Supply: Drift does not exceed 1.0% of bandwidth for ±10% change of heater voltage.
Output: 1.5 volts rms into 100 kilohms resistive load. Generator impedance 750 kilohms.
Harmonic Distortion: 2.0% maximum.
Power Requirements:
0.015 A at 108 volts DC
0.800 A at 6.0 volts DC or rms AC.
Bands of Operation: Standard RDB bands 1.7 through 14.5 kc*.
Size: 4.5" long x 1.45" wide x 1.35" high; occupies 2 sections of Bendix TJS Component Mounting Assembly.
Weight: 0.4 pounds.

*Available for other bridge impedances, sensitivities, and bands of operation on special order. For temperature measurement, ±0.5% change of resistance in one arm produces ±7.5% change of f_o.

Write for complete information.

Pacific Division
Bendix Aviation Corporation
NORTH HOLLYWOOD, CALIF.
Bendix

EAST COAST OFFICE: 475 FIFTH AVE., NEW YORK 17, N.Y.
EXPORT DIVISION: BENDIX INTERNATIONAL, 72 FIFTH AVE., NEW YORK 11, N.Y.

For further information circle 52 on inquiry card.

- SIMPLE, RUGGED, LOW COST, FIELD-REPLACEABLE THERMOSTATIC SYSTEM
- TIGHT SHUT-OFF; Self aligning single seated construction insures tightness.
- SUPER-POWER INSTANTANEOUS RESPONSE; Liquid expansion, throttling action, insures positive, constant control.
- OVERLOAD PROTECTION
- EXTREMELY COMPACT AND STURDY

Write for Bulletin ST-162 Today

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AFFILIATES
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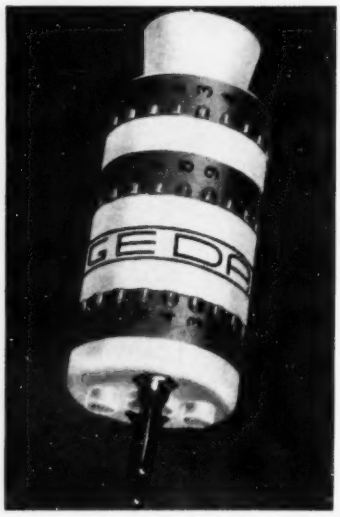
FARRIS FLEXIBLE VALVE CORP.
FARRIS HYDROTORQUE CORP.
FARRIS HYDROSEAL CORP.

For further information circle **53** on inquiry card.

NEW INSTRUMENTS



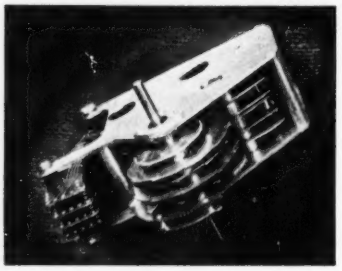
Angle-to-digits Converter

New model of maker's "Analog Digital Converter" converts shaft position into number; operates both up- and down-scale, so that cumulative total can always be displayed after shifting from positive to negative and back (crossing zero). Size and numerical capacity is a function of number of decades or individual ADC units, each being 1.5x1.5x2.25 in. Standard speed is 250 number changes per second—not comparable to electronic computers but "ADC" is offered as a means of digitizing functions which must maintain a zero reference. *—Dep't I, Genisco Inc., 2233 Federal Ave., Los Angeles 64, Calif.*

For further information circle **248** on inquiry card.

Angle-to-digits Converter

New "Type N-P (non-pulsating) Digital Converter," for converting such variables as flows, temperatures,



pressures, etc., directly into numerical form, may also be used to operate recording printers directly, or to actuate tabulating card perforators, electrical typewriters, teletype machines, etc. Device is free of intermittent transfer gears and electronic devices: receives data in the form of shaft rotation and translates it into a two- or three-digit quantity.—*Taller & Cooper, Inc., 75 Front Street, Brooklyn 1, N. Y.*

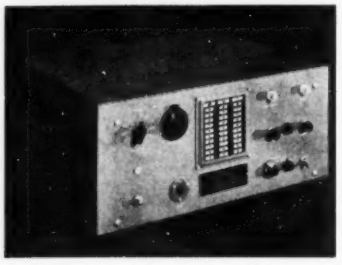
For further information circle **249** on inquiry card.

in 1 percent; top dial permits unit to be set to within 0.1 percent of any range value using a suitable resistance bridge. Banana plugs are on standard 0.75-in. centers.—*Goodyear Aircraft Corporation, Akron 16, Ohio.*

For further information circle **246** on inquiry card.

Volts-to-digits Converter

New "Type 24A Teleducer" automatically converts analog voltages into decimal digits with an accuracy



of 0.1 percent (1000 counts full scale); holds digital representation during a controllable time for display, recording, or any desired readout form: punched cards, electric typewriter, magnetic tape or punched tape.—*Telecomputing Corp., 133 E. Santa Anita Ave., Burbank, Calif.*

For further information circle **247** on inquiry card.

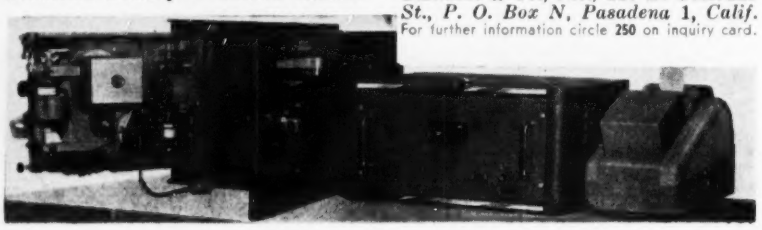
Magnetic Storage Register

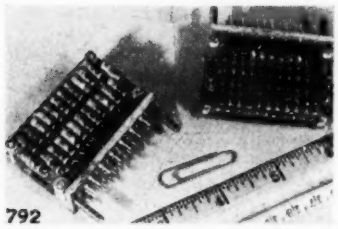
New "Parts Nos. D1143A and D1143B" are said to be "basically different in concept, size, speed, and method of usage from the various magnetic shaft register systems." Magnetic cores are pulsed once, simultaneously, to insert information into them, and then are left quiescent; are all pulsed again, simultaneously, to extract information. Information remains in them for an indefinite pe-

Angle-to-digits Converter

New "Angular Position Encoder" instantaneously indicates angular shaft positions of 360 deg. or less with 0.1 percent accuracy and at shaft speeds up to 100 rpm.; can be connected directly to electromechanical printers or card punch equipment. Coded multi-segment commutator transmits signals to a relay rack, can be quickly and easily attached to a self-balancing potentiometer.—*G. M. Giannini & Co., Inc., 117 E. Colorado St., P. O. Box N, Pasadena 1, Calif.*

For further information circle **250** on inquiry card.





792

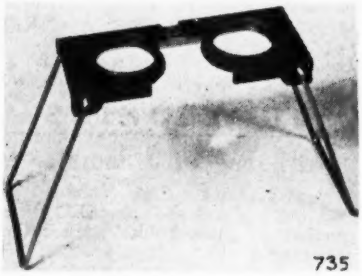
riod of time with no consumption of power: no heat-dissipation problem. Speed is said to "surpass that of any storage system in use": a complete 24-digit number can be read into storage in 8 microseconds, and read out in 3 or 5 microseconds. New register can be incorporated into practically any type of computing or data-handling system.—*Jacobs Instrument Co., Bethesda 14, Md.*

For further information circle 251 on inquiry card

OPTICAL

Pocket Stereoscope

New pocket folding stereoscope for stereoscopic viewing on a table or flat



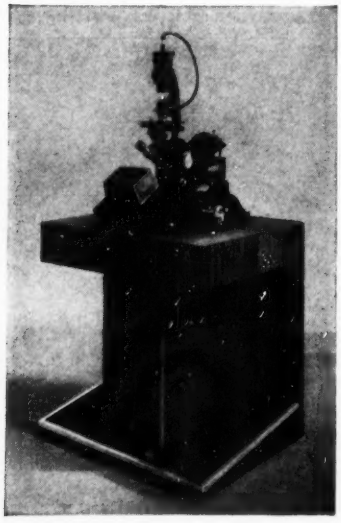
735

surface magnifies 2¼ times, covers photographs up to 3 x 3 in. Interpupillary adjustment is provided.—*Meyer-Opticraft, Inc., 39 W. 60th St., New York 23, N. Y.*

For further information circle 252 on inquiry card.

Universal Microscope

New "Galileo ZC" (Italian-made) universal microscope features comfort and speed with which observer can



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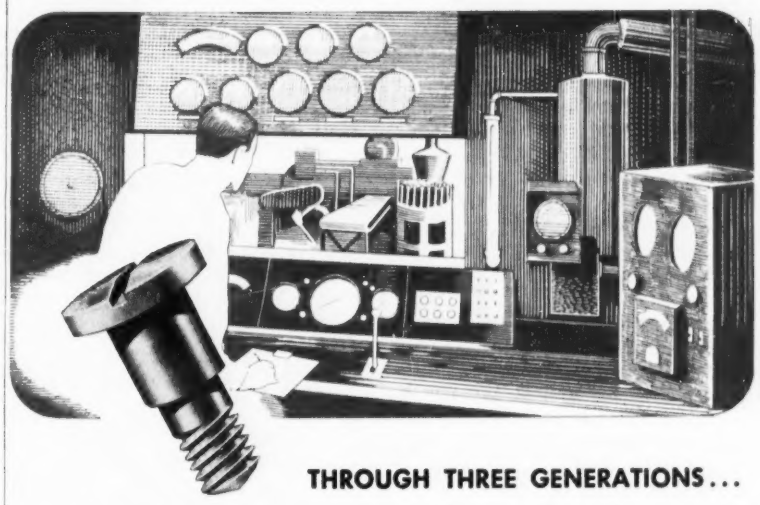

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For further information circle 54 on inquiry card.

One of EDIN'S High Stability Amplifiers Will Meet YOUR Most Critical Recording Requirements

Edin Model 8105 Direct-Coupled Amplifier

Four stage amplifier for study of steady state and varying phenomena. Amplifies signals from .25 mv to 100 volts. Linear response from DC to 2500 cps. with extended range to 10,000 cps. Low drift, low impedance output.

Edin Model 8122 Condenser-Coupled Amplifier

Dual use: high gain condenser-coupled amplifier, voltage gain of 10,000; or low gain direct-coupled amplifier, voltage gain of 250 by a flick of the switch. Records voltage, current characteristics; venous, arterial manometer pressure, vibration studies, electrocardiograms, etc.

Edin Model 8110 Universal Carrier Amplifier

Used with an Edin Oscillograph Recorder, system measures resistive, inductive or capacitive changes. Bridge and galvanometer combination indicates degree of bridge unbalance, plus phase direction. Measures strains, pressure, temperature, displacements, acceleration or force with a transducer bridge circuit.

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For further information circle 55 on inquiry card.

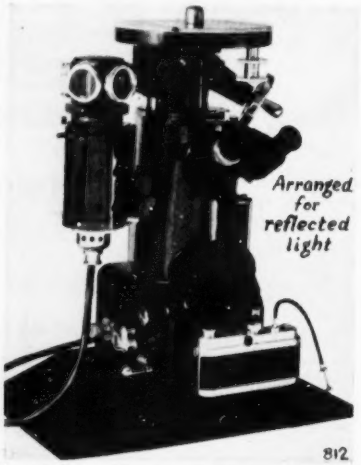
NEW INSTRUMENTS

perform all operations. Magnifications from 4X to 3000X can be run with continuity on camera's ground-glass screen. Without recentering, magnification of any objective setup can be instantly increased or decreased 4 times. Macro-photography down to 5X without disturbing specimens. Eyepiece viewing, and photographing on both still and movie camera can all be done at the same time. A fourth operation, projection up to 20 feet on a 40-inch screen, can also be simultaneously performed when transmitted light is used. Light sources for transmitted and for reflected light, may be used independently or both together. Stage may be loaded with heavy specimens without risk of damage.—*Opplem Co.*, 352 *Fourth Avenue, New York* 10, *N. Y.*

For further information circle 253 on inquiry card.

Universal Microscope

New "OPL" (French-made) microscope is 18 in. high, on 12 x 12-in. base with antivibration suspension. Among features: Micrometer-controlled stag-



812

ing table adjustment rotatable about lens center. Helicoidal cam for fine vertical adjustment. Sources for bright and dark fields, phase contrast, polarization and macrophotography; also transparency-illumination with prism and condenser. Pentagonal turret for quick selection of filters. Ground-glass screen viewing or binocular with adjustable left eyepiece. Adapted for use with 35-mm. camera, micro-hardness testing equipment, etc.—*E. J. Van der Leur*, 60 *Beaver St., New York* 4, *N. Y.*

812

For further information circle 254 on inquiry card.

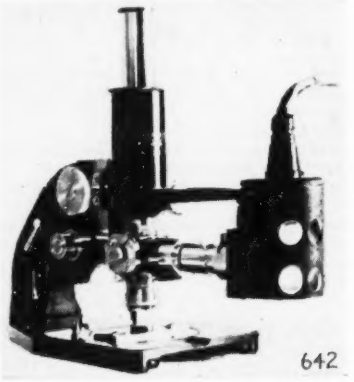
Lens-cleaning Gauze

New "Star Lens Gauze" is not tissue paper but a lintless fabric for removing grease, dirt, finger-marks, etc., from coated or uncoated lenses or prisms. Standard size 7 x 11 in.; others available. Meets UUP-313C Type 1 specs.—*Starr Corp.*, 49 *W. 19th St., New York* 11, *N. Y.*

For further information circle 255 on inquiry card.

Metallurgical Microscope

New model of "Me NB"" Austrian-made portable upright microscope, for surface inspection of opaque objects,



642

can be placed directly on large objects, has convenient illuminator that does not require special transformer. Magnifications from 50x to 1200x. Instantaneous changeover from bright to dark field.—*William J. Hacker & Co., Inc.*, 82 *Beaver St., New York* 5, *N. Y.*

For further information circle 256 on inquiry card.

NUCLEONICS

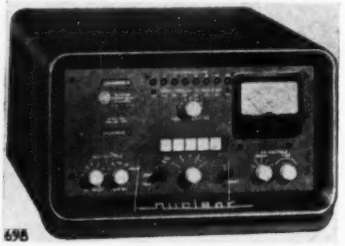
Airborne Dust Sampler

New portable "High Volume Air Sampler," developed at AEC labs, consists of filter holder with interchangeable filter paper system; 30-cfm pump and motor designed for 24-hour sampling; fan housing assembly; flow-rate indicator and a number of types of filter paper depending on flow rate to be used.—*Instruments & Equipment, Inc.*, 489 *Fifth Ave., New York* 17, *N. Y.*

For further information circle 257 on inquiry card.

Scaling Unit

New "Model 182 Versa Scaler" features: (1) electrically-reset timer and register to speed counting procedures in radioisotope laboratories; (2) operation selector switch lights



698

appropriate sections of a plastic panel indicating: count, on, 60-cycle test, high-voltage standby and high-voltage on; (3) Higinbotham scale of 256 with 8-position scale selection switch; (4) coarse and fine high-voltage adjustments; (5) stop-count switch for controlling scaling action; (6) reset switch.—*Nuclear Instrument & Chemical Corp.*, 229 *W. Erie St., Chicago* 10, *Ill.*

For further information circle 258 on inquiry card.

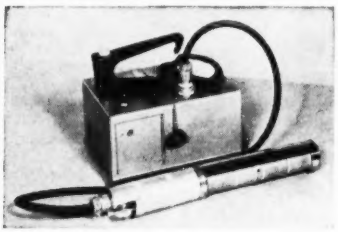
Scintillation Counter

New "SC-2A" Scintillation Counter is 7 in. long, uses new RCA "6199" multiplier phototube and 1 x 1 in. Na I(T1) crystal, giving "extremely high efficiency for gamma detection." —*Nuclear Research Corp., 2563 Grays Ferry Ave., Philadelphia 46, Pa.*

For further information circle 259 on inquiry card.

Contamination Monitor

New "Raychronix Model D-5 Samson Survey Meter" will, when used with new "Raychronix Models D-5A



and D-5B" probes, cover radiation ranges from low-level alpha contamination to 625 mr/hr. gamma radiation; will monitor large flat areas, irregular surfaces, or holes and corners; is also useful in handling of radioactive sources.—*Radioactive Products, Inc., 443 West Congress, Detroit 26, Mich.*

For further information circle 260 on inquiry card.

Air Monitor

New "Model AM-2 Air Monitor" is a mobile unit for detecting, recording and indicating presence of radio-

active materials in air; sounds alarm bell and flashes lights in event of harmful concentration; has three ranges and an automatic range changing mechanism.—*Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.*

For further information circle 261 on inquiry card.

Dosimeters and Charger

New direct-reading quartz-fiber dosimeters meet military requirements, equal or surpass standard commercial specifications. Metal mounting barrels are 1/2 in. in diameter and 4 or 4-1/2 in. long; range coded and serial-numbered with sealed colored bands. Six ranges: 200, 5, 10, 20, 50, and 100 r. These are "Models L-28, L-41, L-42, L-43, L-44 and L-45" respectively. In spite of hermetic pressure seal, units can be quickly dis-

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For further information circle 56 on inquiry card.

Avoid conventional rat's nest wiring

ALDEN BACK CONNECTORS MODERNIZE YOUR PLUG-IN CHASSIS

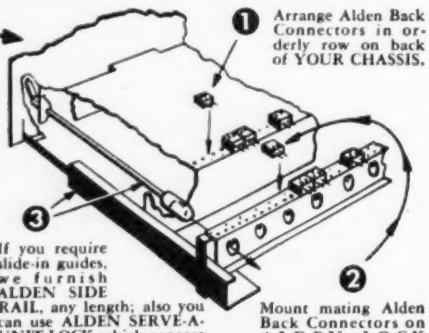
Possible to jump contacts because both sides are instantly accessible.

Critical voltages isolated by wide spacing.

Connectors are spread out in an orderly row, giving a central point of check where all leads are instantly accessible, identified by number and color-coding.

It's as easy as this

Modern design no longer tolerates "blind" connectors and congested rats-nest wiring. Use Alden Back Connectors to convert any chassis to plug-in, with 100% circuit accessibility. It's all done with STANDARD components—no design headaches, no waits, no procurement problems.



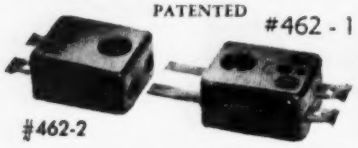
1 Arrange Alden Back Connectors in orderly row on back of YOUR CHASSIS.

2 Mount mating Alden Back Connectors on ALDEN LOCK FRAME. It's prepunched and tapped to screw in the Back Connectors.

3 If you require slide-in guides, we furnish ALDEN SIDE RAIL, any length; also you can use ALDEN SERVE-A-UNIT LOCK which engages prepunched Back Frame to pull in and eject chassis.

ALDEN BACK CONNECTORS

PATENTED #462 - 1



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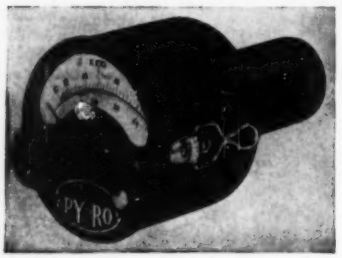
SEND FOR FREE SAMPLES — also request free "Alden Handbook" 226 pages of techniques and components for Unitized Plug-in Unit Construction.

For further information circle 57 on inquiry card.

The *Only* Instrument You Need to Tell Spot Temperatures *Instantly!*



Just sight it . . . and press the button!

NEW PYRO RADIATION PYROMETER

Any operator can determine spot temperatures in kilns, fire boxes, furnaces, ovens, etc., *accurately—instantly*—with the New **Pyro** Radiation **Pyrometer.** No thermocouples, lead wires or other accessories needed—the **PYRO** is completely self-contained. Just sight it at the object . . . and press the button. Temperature indicated instantly on large direct-reading dial. Two double ranges available 1000/1800—1800/2600° and 1400/2400—2400/3600°F. *Write for FREE Catalog No.* 100.

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For further information circle 58 on inquiry card.

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The fastest to operate and most practical principle ever devised for providing a tool to carry quickly interchangeable steel stamping type for serial and random numbering.

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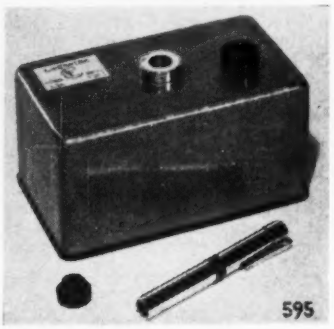
For further information circle 59 on inquiry card.

NEW INSTRUMENTS



595

assembled. All models are charged by means of "Model L-24 Dosimeter Charger" (also illustrated).—*Landsverk Electrometer Co.*, 550 *W. Garfield Ave., Glendale, Calif.*

For further information circle 262 on inquiry card.

Medical Ratemeter

New "Model 112 Scintillator" is a portable (15-lb.) scintillation counter for thyroid uptake studies, brain tumor localization and laboratory use. Ranges are 0.025, 0.05, 0.25, 1, 5 and 25 mr/hr.—*Precision Radiation Instruments*, 2235 *S. La Brea Ave., Los Angeles* 16, *Calif.*

785

For further information circle 263 on inquiry card.

Midget Roentgen-meters

New set of three midget R-Meters, "Models L-101, L-102 and L-103," have ranges of 500 mr., 5 r., and 50 r. respectively; are sealed against dirt and

596

moisture, will stand rough handling, have only slight energy dependence (for which a correction curve is provided) and can be exposed directly in hard x-ray and gamma ray beams without shielding insulation. New R-meters and "Model L-61 Charger-Reader" come with carrying case.—*Landsverk Electrometer Co.*, 500 *W. Garfield Ave., Glendale* 4, *Calif.*

For further information circle **264** on inquiry card.

Encapsulation Service on Radioactive Sources

New encapsulation services on radioactive sources are announced: cobalt-60 sources for industrial radiography; other types of radioactivity. Capsules and carrying containers supplied by either maker or customer.—*Radioactive Products, Inc.*, 433 *W. Congress, Detroit* 26, *Mich.*

For further information circle **265** on inquiry card.

FOR THE LABORATORY

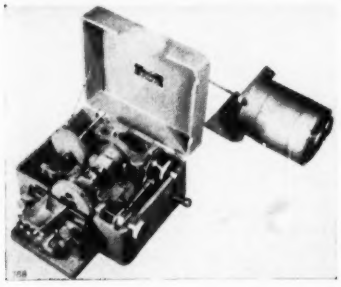
Inert Filter Medium

New "Porous Kel-F (polychlorotrifluoroethylene) filtration medium is completely resistant to all strong acids, caustics, oxidizing agents and common organic solvents at temperatures up to 300 F. Ultimate tensile strength 900 psi.; modulus of elasticity 1800 psi.; mean pore opening 15 microns; currently available in disks up to 12 in. diam., 1/16 and 1/8 in. thick.—*Porous Plastic Filter Co.*, 30 *Sea Cliff Ave., Glen Cove, N. Y.*

For further information circle **266** on inquiry card.

Ultra Microtome

New "Model 3 Gettner Ultramicrotome" is motor-driven and all-rotary; is designed for cutting thin-sections (0.1 micron or better) for electron



microscopy and provided with a gear shift to permit cutting thick sections (up to 10 microns). Among ten new features is a trough (mounted on knife holder and using knife as its end wall) filled to level of cutting edge with an alcohol-water mixture, which floats newly-cut section onto its surface, thereby immediately straightening and extending section.—*Process & Instruments*, 60 *Greenpoint Ave., Brooklyn* 22, *N. Y.*

For further information circle **267** on inquiry card.

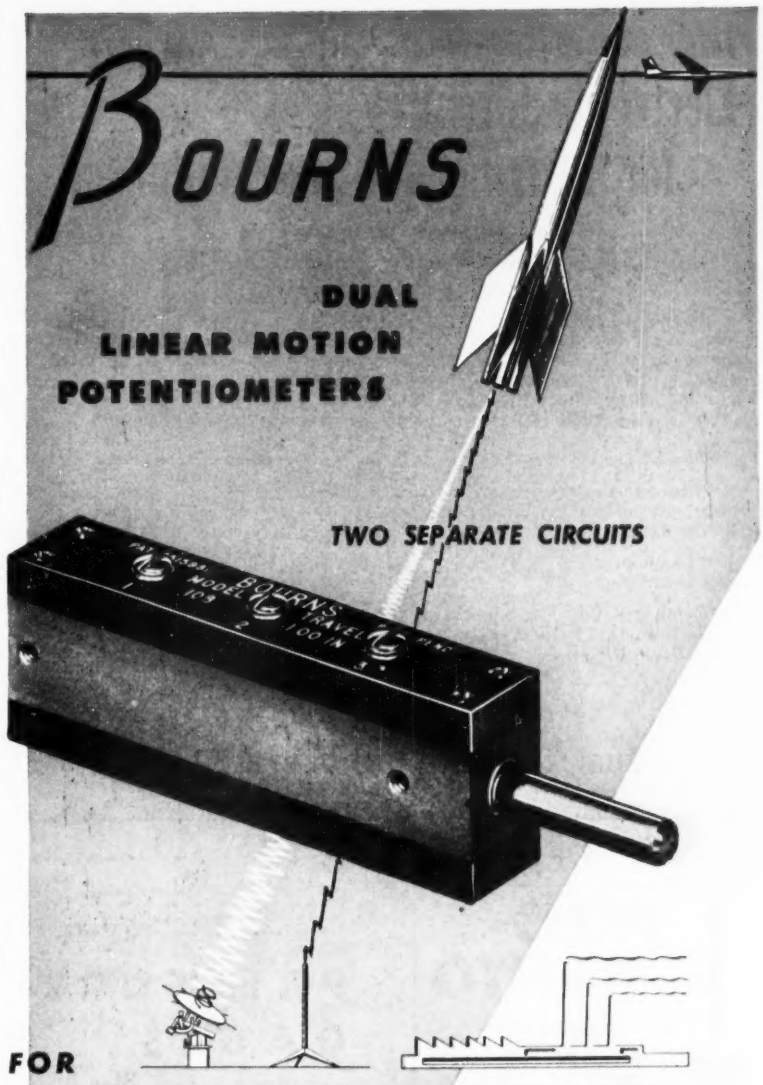
Laboratory Heating Unit

New "No. 2020 Speedi-Heet Duplex Heater" for ASTM petroleum tests and other laboratory heating operations, has new reflector type heating element which eliminates lower refrac-

BOURNS

DUAL LINEAR MOTION POTENTIOMETERS

TWO SEPARATE CIRCUITS



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Designed for precise instrumentation in automatic control circuits for aircraft, guided missiles and general industry, BOURNS linear motion potentiometers accurately translate mechanical position or movement into two independent signals . . . one signal often used for feed-back control and the other for telemetering.

This dual instrument possesses all the advantages of two single potentiometers and in addition, saves space, weight and installation time. With this wire-wound potentiometer a resolution of .001 inch is obtainable in standard ranges from 1 to 6 inches.

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Technical Bulletin on request, Dept. 29

For further information circle **60** on inquiry card.

Just Published—the "Instrument Electronics" book

Electronic Circuitry for Instruments and Equipment

By MILTON H. ARONSON
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The first book of its kind

A Complete home-study TEXT and COURSE, with 458 multiple-choice home-study test items on basic electronic circuitry for instruments, communications, TV, laboratory apparatus, and military equipment. (Printed serially in *Instruments* as "Instrument Electronics.")

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For further information circle 61 on inquiry card.

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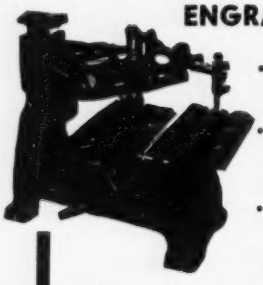

- Ratios from 1.7:1 to 7:1
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A high precision, sturdily constructed, widely adaptable machine for engraving steel stamps, dies, other metals, plastic, fibre, wood, etc.

By simple attachment of additional accessories, this machine may also be used for ELECTRICAL MARKING and ACID ETCHING.

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For further information circle 62 on inquiry card.

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Fine pressure gages should also be safe gages.

Gages so built that in case of tube rupture no one will be injured.

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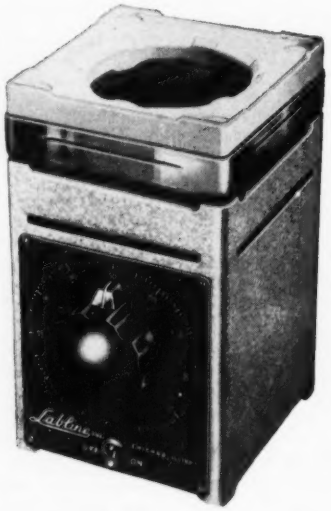
For further information circle 63 on inquiry card.

NEW INSTRUMENTS

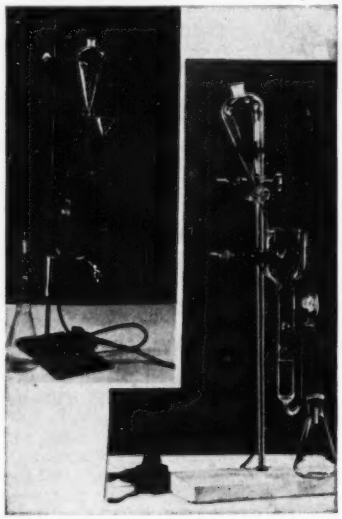


tory. Nickel rod core and Nichrome heating coils develop maximum heat in 15 seconds; cool to black heat in 7 seconds. Cast aluminum case remains cool at all times. Removable support rod provides easy method of mounting apparatus on heater, or fastening heater to a setup frame. Dimensions: 5x5x9 in.—*Labline, Inc., 217 N. Desplaines St., Chicago 6, Ill.*

For further information circle 268 on inquiry card.

Schmall Apparatus

New "Schmall Apparatus" is embodiment of an entirely new method for extraction and determination of

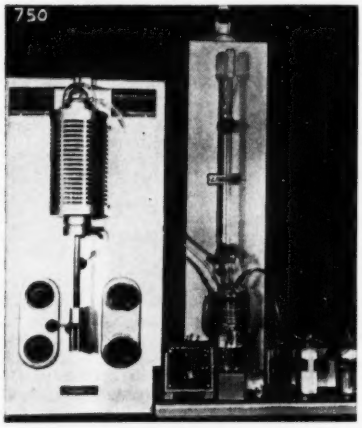


salts of organic bases and acids, which not only facilitates sample preparation, but makes extraction automatic, eliminates washings and minimizes labor cost of analysis. Two types of liquid-liquid extractors are available. One (left in photo) is for use with solvents lighter than water; the other for those heavier than water.—*Scientific Glass Apparatus Co. Inc., Bloomfield, N. J.*

For further information circle 269 on inquiry card.

Induction Furnace for Carbon and Sulphur in Iron

New "High Frequency Combustion Unit" employs radiofrequency induction principle to heat iron or steel

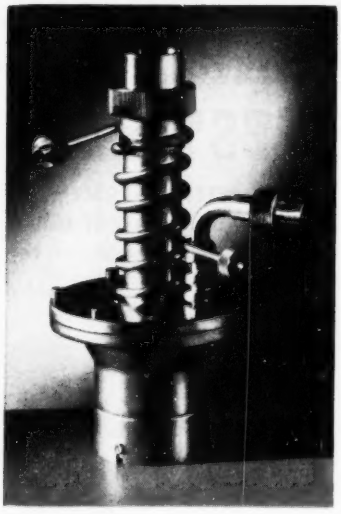


sample only: crucibles, etc., are heated only by sample. Both carbon and sulphur in all types of ferrous alloys can be determined, and in ten minutes as against half an hour or more.—*Laboratory Div., Lindberg Engineering Co., 2450 W. Hubbard St., Chicago 12, Ill.*

For further information circle 270 on inquiry card.

Oil Diffusion Pumps

New "Supervac OD-25" oil diffusion pump is exceptionally easy to take apart for cleaning and may be quick-



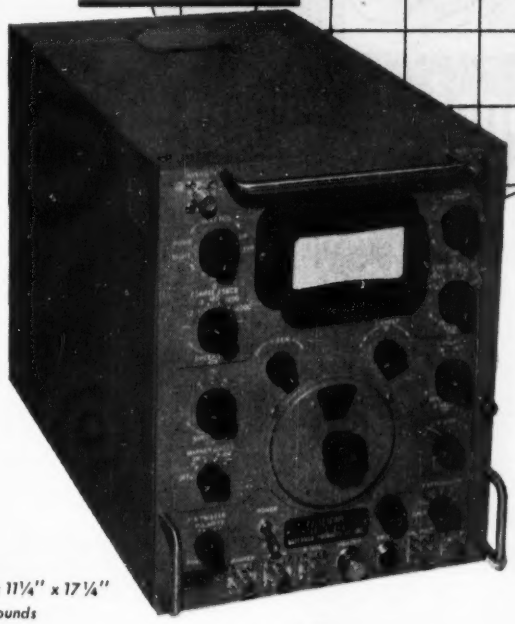
ly connected or disconnected. All parts are of cold-rolled steel except brass couplings and copper cooling coil. Inside is copper-plated to prevent rusting.—*Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.*

For further information circle 271 on inquiry card.

X-ray Darkroom Cabinets

New "Westline" all-metal floor and wall cabinets for use in x-ray darkrooms feature rounded corners and tubular shelves for fast efficient cleaning. Film loading is made easy by

the Waterman SAR PULSESCOPE®



MODEL S-4-A

Size:
9⅛" x 11¼" x 17¼"
31.5 Pounds

ANOTHER EXAMPLE OF Waterman PIONEERING...

The SAR PULSESCOPE, model S-4-A, is the culmination of compactness, portability, and precision in a pulse measuring instrument for radar, TV and all electronic work. An optional delay of 0.55 microseconds assures entire observation of pulses. A pulse rise time of 0.035 microseconds is provided thru the video amplifier whose sensitivity is 0.5V p to p/inch. The response extends beyond 11 MC. A and S sweeps cover a continuous range from 1.2 to 12,000 microseconds. A directly calibrated dial permits R sweep delay readings of 3 to 10,000 microseconds in three ranges. In addition, R sweeps are continuously variable from 2.4 to 24 microseconds; further expanding the oscilloscope's usefulness. Built-in crystal markers of 10 or 50 microseconds make its time measuring capabilities complete. The SAR PULSESCOPE can be supplied directly calibrated in yards for radar type measurements. Operation from 50 to 1000 c.p.s. at 115 volts widens the field application of the unit. Countless other outstanding features of the SAR PULSESCOPE round out its distinguished performance.

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MEMO... Write for details today!

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S-5-A	LAB	PULSESCOPE
S-11-A	INDUSTRIAL	POCKETSCOPE®
S-12-B	JANized	RAKSCOPE®
S-14-A	HIGH GAIN	POCKETSCOPE
S-14-B	WIDE BAND	POCKETSCOPE
S-15-A	TWIN TUBE	POCKETSCOPE

Also RAYONIC® Cathode Ray Tubes and Other Associated Equipment

WATERMAN PRODUCTS

For further information circle 64 on inquiry card.

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TUBE
FITTINGS
(in Stainless or Monel)
are better
FIVE
WAYS

1. DOUBLE SEALED . . . metal-to-metal seal *plus* Teflon insures vacuum tight connection.

2. EASY TO USE . . . and reuse . . . install fast.

3. FATIGUE PROOF design and operation.

4. PRESSURE SAFE construction exceeds tube strength.

5. LOW INITIAL COST . . . interchangeable parts.

Over 1200 combinations for tubing through 1" O. D. . . . ready for prompt shipment through leading Stainless distributors.

THE SPECIAL SCREW PRODUCTS CO.

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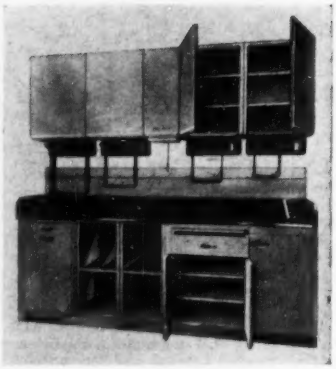
Literature covering Koncentrik fittings, and Powell valves with machined-in Koncentrik connections, now available. Write today.

For further information circle **65** on inquiry card.



convenient cassette, film, and hanger storage locations. Trash disposal drop, film identification printer unit, and built-in cabinet safelight are available if desired. Variety of sizes.—*Section X, Westinghouse Electric Corp.*, 2519 *Wilkens Ave., Baltimore* 3, *Md.*

For further information circle **272** on inquiry card.

FOR THE TESTING DEPARTMENT

Impact Tester for Vinyl Film

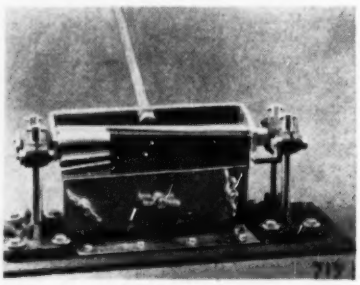
New low-temperature impact tester for Vinyl plastic film (recommended commercial standard TS-5165, also

Plastic Coated and Film Association) has been designed for improved appearance and durability; includes a mechanical release fixture to assure uniform results when used by different operators.—*U. S. Testing Co., Inc., Hoboken, N. J.*

For further information circle **273** on inquiry card.

Distensibility Tester

New "Conical Mandrel Tester" is for determination of distensibility of organic coatings: specimen is clamped

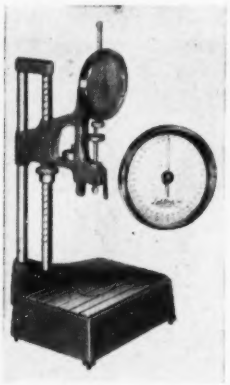


in vertical position between cone and the draw-bar; lever is then moved to wrap panel uniformly around cone. —*Universal Aviation Equipment, Inc.*, 187 *Lafayette St., New York* 13, *N. Y.*

For further information circle **274** on inquiry card.

Penetrometer

New "No. 4100" penetrometer not only complies with ASTM D5, D217, etc., but embodies novel features said



to make it "the most accurate unit of its kind now available." Universal design accommodates all types of penetration needles and cones.—*Labline, Inc.*, 217 *N. Desplaines St., Chicago* 6, *Ill.*

For further information circle **275** on inquiry card.

Tensile Tester

New "Universal Tensile Tester" elongates at constant rate to maximum of 4 inches; permits obtaining charts (on suitable electrical recorder) of force-elongation, force-time, hysteresis, etc. Specimen may be tested dry or in a solution, at room or con-

HARDNESS TESTING...

done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 47 years.

In general use for specification purposes. Simple, sturdy Comparatively inexpensive.

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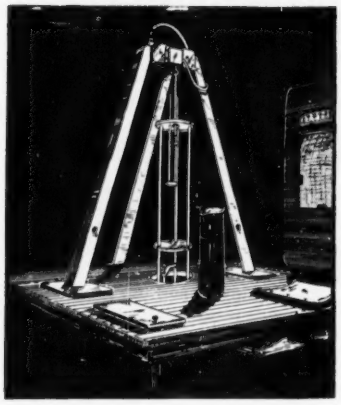
Jamaica 35, N. Y.

For further information circle **66** on inquiry card.

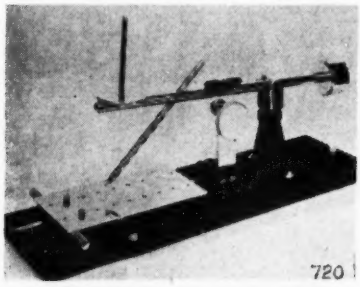


trolled temperature. Among features: instant stop or reversal; no backlash, no inertia from instrument parts; easy calibration; time or elongation units on recorder chart.—*G. F. Bush Associates, Box* 175, *Princeton, N. J.*

For further information circle 276 on inquiry card.

Scratch-adhesion Tester

New tester measures scratch-adhesion levels by making ten successive

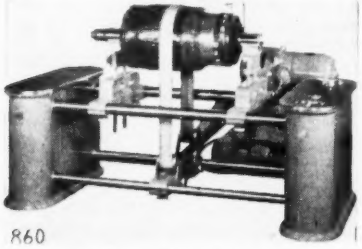


scratches with 0.5-kg. increments of load on stylus.—*Universal Aviation Equipment, Inc.,* 187 *Lafayette St., New York* 13, *N. Y.*

For further information circle 277 on inquiry card.

Balancing Machines

New "Raydyne Dynamic Balancing Machines" indicate static, dynamic and total unbalance, have universal



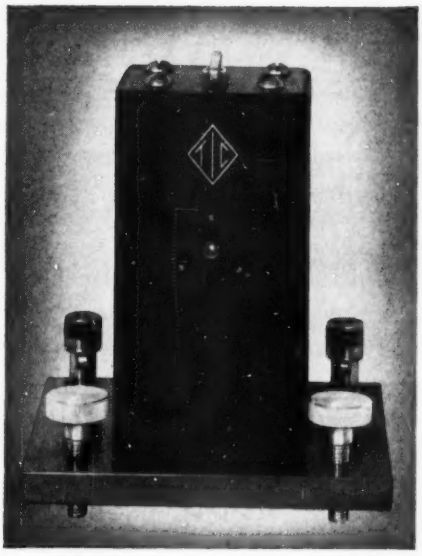
vee bearings which take all shaft sizes; do not require technical personnel for operation. Illustrated is new "Model 50" (heavy duty).—*Welch Mfg. Co.,* 920 *W. Laurel St., Springfield, Ill.*

For further information circle 278 on inquiry card.

Balancing Machines

New models of "Schenck" (German-made) electrodynamic balancing machines determine amount and location

GALVANOMETERS
for special applications



Super Sensitive

SINGLE UNITS FOR PRECISE LABORATORY MEASUREMENTS

Specifications:

Size: Height 5", Base 4" square Weight 1 pound, 8 ounces

Sensitivity: 15" Deflection per microampere at a distance of one meter.

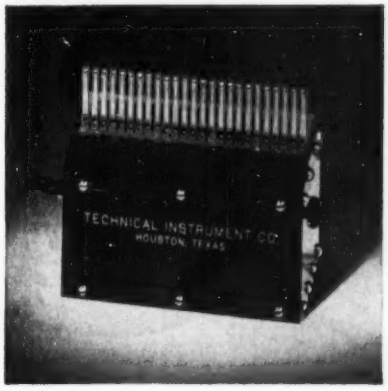
Frequency: One cycle per second natural frequency. Other frequencies and sensitivities available.

Resistance: 4000 ohms.

Price: $100.00 complete.

High Quality

MULTIPLE-ELEMENT GALVANOMETERS AT LOW COST



Size: Height 3", Width 2"

Length: Dependent upon number of element positions which are on .140" centers and in quantities of 4 to 50 per housing.

Frequency: Standard 140 cps. Other frequencies available on special order.

Sensitivity: Standard 15 ohm 140 cycle suspension gives a 7" deflection per miliampere at a distance of 12".

Mirrors: Standard 10" radius of curvature. Spherical. First surface .040" wide x .115" long. Other focal lengths available.

Price: 25 Elements in 25 position housing without vertical adjustment $1,000.00. Other models with vertical adjustment and isolated circuits at slight extra cost.

Write us for quotation on your special galvanometer needs.

TECHNICAL INSTRUMENT CO., INC.

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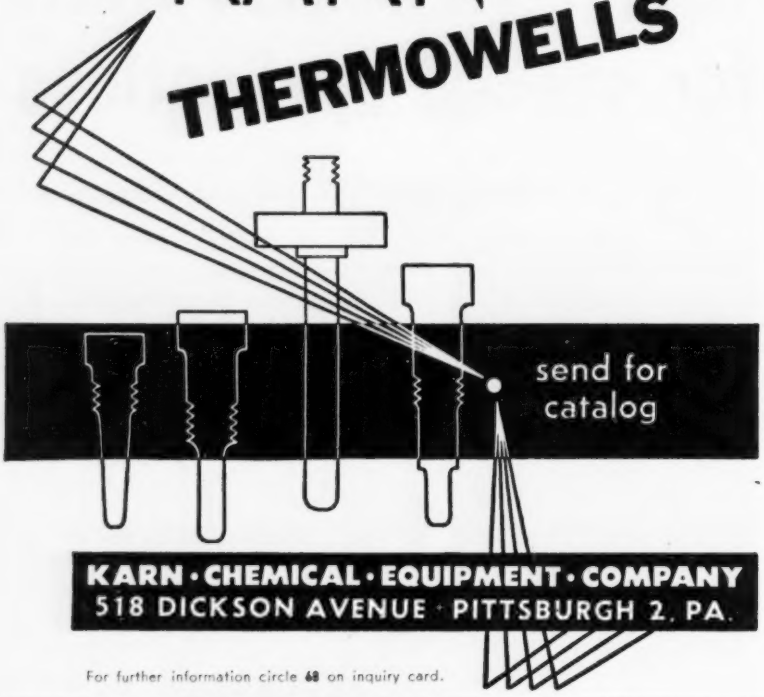
HOUSTON 6, TEXAS

For further information circle 67 on inquiry card.

KARN

THERMOWELLS



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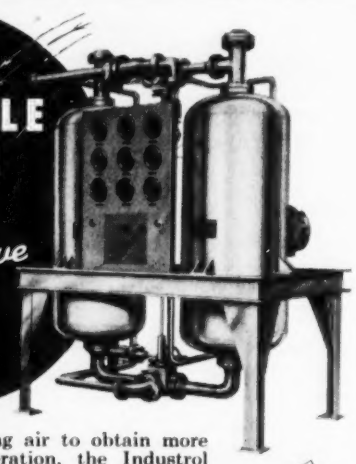
518 DICKSON AVENUE · PITTSBURGH 2, PA.

For further information circle 68 on inquiry card.

for DEPENDABLE Instrument Operation You Must Have CLEAN-DRY AIR



When your problem involves drying air to obtain more efficient, dependable instrument operation, the Industrol Dynamic Dehumidifier offers you a practical low cost solution.

Dryers are offered with manual, semi-automatic or fully automatic control. Heat regeneration of desiccant is supplied by either electricity or steam.

An Industrol Dynamic Dehumidifier used in conjunction with the Industrol Centrisorb Filter is the ideal combination to give you the clean, dry air that spells trouble-free instrument operation.

Prove to yourself why more plant operating men are specifying Industrol. A qualified engineer is available to consult with you on your dryer problems.

Send for Bulletin DD-150

2366

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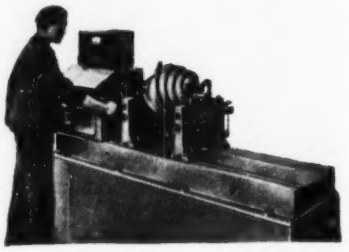
SUBSIDIARY OF TRINITY EQUIPMENT CORPORATION
494 Westfield Ave., East • Roselle Park, New Jersey

For further information circle 69 on inquiry card.

NEW INSTRUMENTS

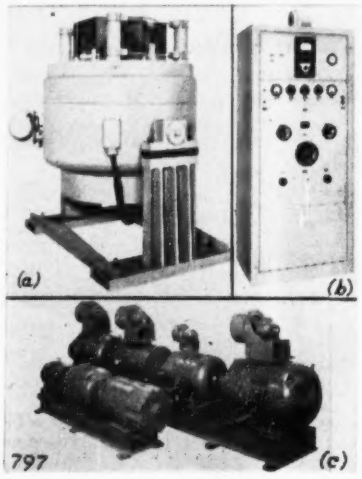


of dynamic and static unbalance in rotating parts. Nine models have weight capacities from a few ounces to over 100 tons.—*Cosa Corp.*, 405 *Lexington Ave., New York* 17, *N. Y.*

For further information circle 279 on inquiry card.

Vibration Exciter

New "Model C-100 Exciter," said to be largest commercial general-purpose vibration generator, is of



electromagnetic type, delivers 10,000 lbs. force output. Shaker-table forged-steel flexures insure straight-line motion and no resonances in equipment's operating range of 5 to 500 cps., and permit placing heavy loads on table without sacrificing a large portion of available 0.5-in. stroke. Control panel (b) has completely interlocking controls. Power supply (c) has three alternators of pure wave form; 50-hp. a-c. motor; d-c. generator, field exciter and motor.—*MB Mfg. Co., Inc., New Haven, Conn.*

For further information circle 280 on inquiry card.

Insulated Test Clips

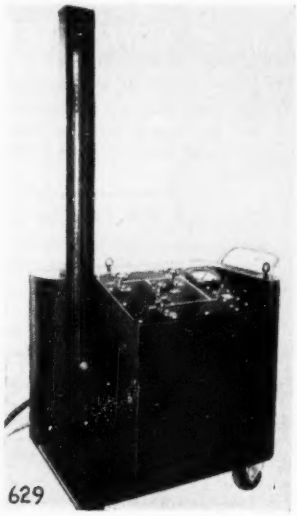
New "Model 1410B" nylon-insulated test clips provide positive clip connection to all standard phone-tip test

prods: phosphor-bronze spring collar accepts standard prod with an electrically and mechanically positive grip.—*Industrial Devices, Inc., Edgewater, N. J.*

For further information circle 281 on inquiry card.

Leak Testers

New manometer leak test machines, operating on air-pressure-drop principle, were developed initially for final tests in aircraft fuel and hydraulic circuits. Units are adjustable throughout range 0 to 20 psi., and repeatable within 2-in. water column. Plex-

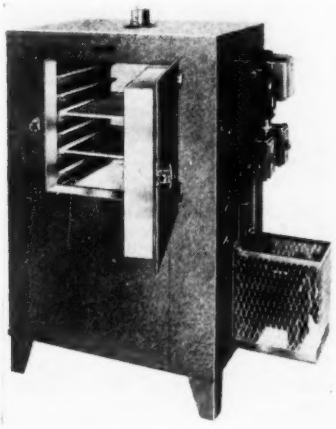


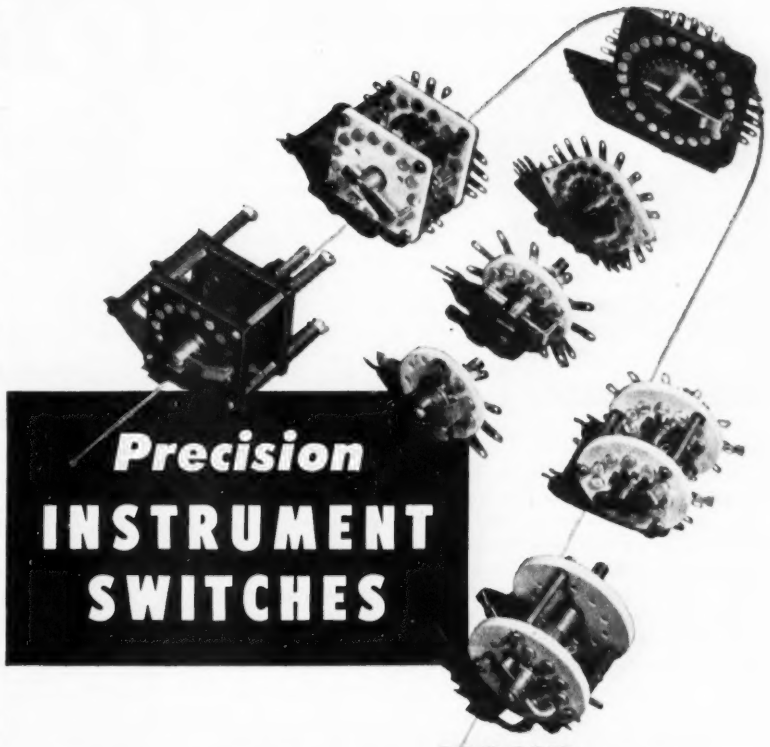
iglass door behind which adjustable instruments are located has a receptacle for a card certifying pressure setting of unit, to prevent tampering. A manual by-pass valve enables rapid filling of receptacle to be leak-tested.—*Device Engineering*, 1701 *Walnut St., Philadelphia 3, Pa.*

For further information circle 282 on inquiry card.

Cabinet Ovens

New cabinet ovens are equipped with a high-pressure motor-driven blower which propels heated air in a definite air-flow pattern through work chamber. Other features include: indicating temperature control; high and low heat switch; manual interlock for purge period; electrical interlock for turn-off of heat in case of blower motor failure. Available in horizontal





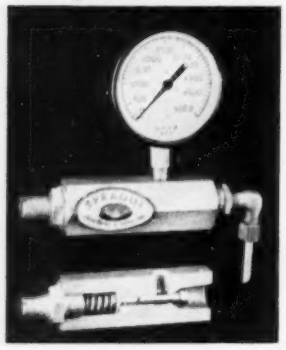
STOCK MODELS FOR *YOUR* JOB

There's nothing like stock models of Shallcross Instrument Switches for cutting equipment cost and design problems. For over 20 years Shallcross has made scores of basic switch types with countless variations for practically every electric-electronic application. Single or multi-deck types having up to 60 non-shorting positions are regularly produced. Contact resistance less than 0.001 ohm is a feature of many types. Several unique switches—usually "Special items" with other manufacturers—can quickly be supplied by Shallcross from stock. For a fast solution to any problem involving rotary switches, write to SHALLCROSS MANUFACTURING CO., Pusey & Lincoln Aves., Collingdale, Pa.

Shallcross

For further information circle 70 on inquiry card.

PROTECT YOUR GAGES!



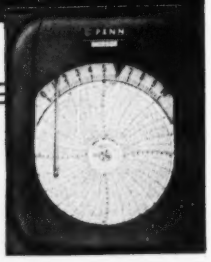
New Shut Off Valve automatically cuts out gage from system when hydraulic or pneumatic pressure goes beyond its operating limit. Automatically opens when pressure is again within operating range of gage. (Cut-in point approx. 80% of set cut-out point.) Available for low pressures—30, 60, 100, 200 and 300 PSI. and high pressures—500, 1000, 1500, 2000, 2500, 3000 and 5000 PSI. Sprague Gage Shut Offs installed in a hydraulic system with multiple gages of various ranges, save valuable man hours. They eliminate the necessity of the operator opening and closing manually operated shut off valves for the various gages in the system. Supplied with standard pipe thread connections but can also be furnished with AN adaptors for aircraft fittings. Connection to the system is made at the end of shut off, ½" pipe thread. Connection to gage is made on the side of shut off, ¼" pipe thread. Overall length 5½ inches. Body is 1½ inch hexagon stock. Other models with bronze or stainless steel bodies available for water service. Finest construction. Individually tested and fully guaranteed. Write today for bulletin.

SPRAGUE ENGINEERING & SALES CORP.
1144 West 135th St., Gardena, Calif.
Designers and Manufacturers of Precision Aircraft and Industrial Test Equipment.

For further information circle **71** on inquiry card.

AREA METERS

PENN



Electric or Electronic LINAMETER

PENN Mechanical LINAMETER

For corrosive fluids, viscous liquids, pulps, and slurries, for pulsating flows, inadequate straight run of pipe, small flows and wide range of flows.

WRITE FOR NEW CATALOG 650
Contains capacity tables, installation diagrams, other useful flow data.

More than 40 Years' Experience . . . more than 10,000 Installations

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Indicating, Recording, Controlling Instruments

For further information circle **72** on inquiry card.

The Versatile

TYPE 130A1 PULSE TRANSFORMER for Low-Power Applications

SUPERIOR ELECTRICAL CHARACTERISTICS—Provides short rise time—small droop—appropriate impedance levels for operation in low-power circuits.
VERSATILITY—three winding design provides option of impedance and turns ratios.
CONVENIENT MOUNTING—compact, through-panel mounting same as standard miniature tube socket.

Immediate delivery on sample quantities.
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DIGITAL COMPUTERS • DATA HANDLING SYSTEMS • MAGNETIC STORAGE SYSTEMS • INSTRUMENTS • ANALOG MAGNETIC RECORDING SYSTEMS • COMPUTING SERVICE

For further information circle **73** on inquiry card.

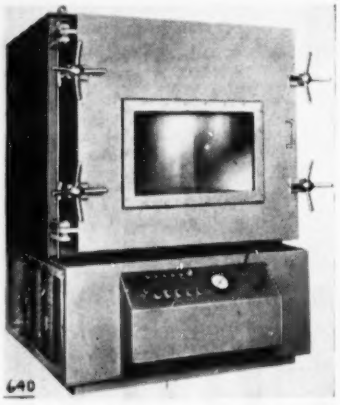
NEW INSTRUMENTS

or vertical flow; temperatures to 650 F. and 850 F., for 220- or 440-volt operation.—*Grieve-Hendry Co., Inc.*, 1811-19 *W. Lake St., Chicago* 12, *Ill.*

For further information circle **283** on inquiry card.

Temperature, Humidity and Pressure Test Chamber

New "Altitude Simulation Chamber" is said to provide an extremely wide range of temperature, vacuum and

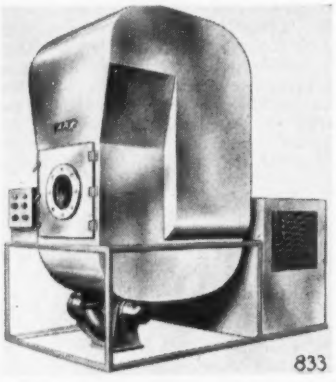


humidity conditions. Heavy-duty control circuits with automatic safety interlocks assure fool-proof operation. Optional equipment: program heating, cooling and humidity cycles, with automatic recorder for controlling and integrating temperature, humidity and altitude.—*Murphy & Miller, Inc.*, 1322 *S. Michigan Ave., Chicago, Ill.*

For further information circle **284** on inquiry card.

Sand and Dust Test Unit

New facility for sand and dust environmental testing is said to represent "new concepts of streamlined air flow which have made it possible



to lower power necessary to move air and reduce floor space required while at the same time minimizing air side pressure drop." It is designed to meet MIL-E-5272A and MIL-T-5422A. Other feature: automatic temperature and dust-density control, and humidity indication. Units are available in several sizes, ready for installation. —*American Research Corp., Bristol, Conn.*

For further information circle **285** on inquiry card.

"Our NORELCO X-ray Diffraction equipment is unique for attacking research and production problems. It puts directly into evidence dimensions of atomic magnitude — beyond the resolving power of any present microscope. We consider it an essential laboratory instrument."

POLAROID CORPORATION

Atomic "Third Degree"

gives Industry the Answers to Better Methods and Products

NORELCO X-ray equipment offers manufacturers an atomic "third degree," yielding answers in product development to be found in no other way. Its analysis of complex atomic structures, for instance, played an important part in the development of the famous Polaroid Land Camera and the Polaroid H-type polarizer used in sunglasses and military filters. NORELCO X-ray Diffraction, X-ray Spectrometry, Fluorescence and Absorption Analysis equipment may hold the answer to *your* research problems. Write us for free consultation at your convenience.

Typical Users

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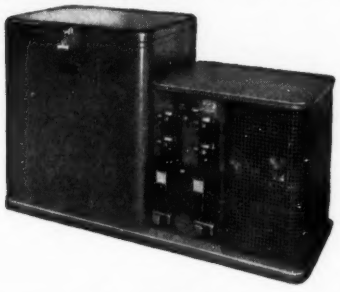
Dept. IM-5 • 100 East 42nd St., New York 17, N. Y.

In Canada: Rogers Majestic Electronics Ltd., 11-19 Brentcliffe Road, Leaside, Toronto 17, Ontario

For further information circle 74 on inquiry card.

Chilling Chamber

New "Model T-120" industrial chilling machine provides chilling capacity down to minus 140 F. Thermal capacity 1200 b.t.u. per hour at minus 120 F.; chamber capacity approx. 7.5 cu. ft.—*Sub-Zero Products Co., Reading Rd. at Paddock, Cincinnati 29, Ohio.*



For further information circle 286 on inquiry card.

FOR INSTRUMENT SHOP

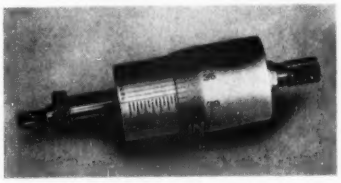
Soldering Flux Test Kit

New "Divco Soldering Flux Test Kit" outdoes maker's previous kit in every respect: double the test quantities of fluxes, thinners, residue removers, and chemical wire strippers; includes 24 items and "Divco Soldering Flux Chart No. 52"—*Division Lead Co., 7742 W. 61st Place, Summit, Ill.*

For further information circle 287 on inquiry card.

Micrometer Head

New Tavannes (Swiss) non-rotating spindle micrometer head has a 1-in. range, reads by vernier to 0.0001-in.; is standard equipment on "Boeckeler Model 1" optical micrometer; is available by itself.—*Boeckeler Instrument Co., 29 E. Rillito St., Tucson, Ariz.*



For further information circle 288 on inquiry card.

Auto-Collimator

New improved model of "Microptic Auto-Collimator" is free from effects of temperature change, normal shop vibration, or wear. It gives readings comparable to a level of forty times

THE ERA TYPE 416C3 HIGH-GAIN PLUG-IN AMPLIFIER

Maximum voltage gain of 9,000—Case dimensions only 3" x 2¼" x 1⅞"—Frequency response substantially flat from 2 to 1,000 cps.—Reduces power supply surges by a factor of 5 and ripple by a factor of 25 in output—Particularly well adapted to applications involving low-level low-frequency inputs. Important application is its use in wide-range integrating circuits in which integration is achieved by a stabilizing negative-feedback circuit.

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For further information circle 75 on inquiry card.

Gives you
TWICE AS MUCH FLOW CONTROL

CUTS PRESSURE FLUCTUATION CHANGES IN HALF

THE THOMAS **MAGNA-STROKE*** PATENT APPLIED FOR*

A NEW DEVELOPMENT OF DESIGN AVAILABLE IN ALL N.G.E. *Wilgus* REGULATING VALVES for steam, liquids or gas

Magna-Stroke is a gear train working at a ratio of 2:1 giving twice the stroke at the inner valve as at the diaphram.

For Process Men Everywhere Who Want Better Control

Through the use of Magna-Stroke action double efficiency is received from regulating valves. Any increase or decrease in pressure to be secured by the opening and closing of the inner valve is done so at a ratio of two to one, since the action of the diaphram is doubled at the inner valve.

Liquid or vapors which are to be maintained automatically at a desired pressure within a close limit can be maintained at half the variation due to Magna-Stroke action of doubling the pressure effect.

Pilot Instrument Actuated Valves Work Twice As Fast

For example, if 30 seconds of time is required to actuate the valve, by pressure or temperature changes in the system, the Magna-Stroke valve will in turn respond in half the time, or 15 seconds.

Bonus Qualities Of N. G. E. Wilgus Regulating Valves Equipped With Thomas Magna-Stroke Action

Valves have smaller diaphragms thus effecting better control. When Magna-Stroke action is reversed, double the power is achieved. Just one more improvement of design which makes N. G. E. Wilgus Regulating Valves the leaders of the industry.

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I am interested in Magna-Stroke action as contained in
☐ Reducing Regulators ☐ Back Pressure Regulators ☐ Motor Valves

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COMPANY _____
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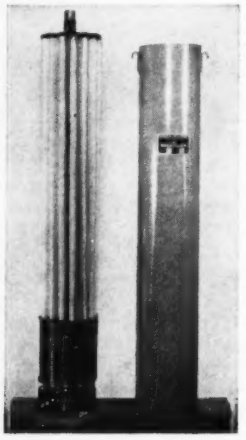
For further information circle **76** on inquiry card.

normal accuracy and in any plane—horizontal, vertical, or inclined.—*Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.*

For further information circle **289** on inquiry card.

Instrument Air Cleaner

New "Model A-100-D Condensi-filter," for filtering and dehydrating compressed air, uses new type of disposable filter cartridge which



provides greater economy of operation than did previous models; over 24 square feet of filtering area (increase of 37 percent over previous models). Under normal working conditions, unit will operate five to six months without renewing filter.—*Hankison Corp., 352 Biltmore Bldg., 951 Banksville Rd., Pittsburgh, Pa.*

For further information circle **290** on inquiry card.

Pneumatic Gage

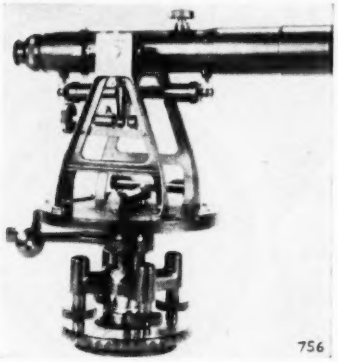
New 'Model G" of "Air-O-Limit Comparator" features a new larger gage dial and use of long-wearing

standard gaging plugs; is furnished with either of two magnifications, 10,000X or 5,000X. Hand gage attachments, both straight type and L type, are available.—*Pratt & Whitney, Div. Niles-Bement-Pond Co., West Hartford 1, Conn.*

For further information circle **291** on inquiry card.

Jig Alignment Transit

New "Optopiane" is industrial model of maker's "Precise Transit" for facilitating jig and fixture location



and alignment. It establishes horizontal and vertical planes necessary in locating and setting up jigs for sectional assembly.—*W. & L. E. Gurley, Troy, N. Y.*

For further information circle **292** on inquiry card.

Lens-handling Tool

New "Model 230 Lensetter" is a suction-cup tool for picking up lenses, etc., and placing them gently into deep cylinders and other cavities. Smaller suction cup in upper end for thumb to enable holding or release of suction grip.—*Larrimore Sales Co., P. O. Box 1234, St. Louis 1, Mo.*

For further information circle **293** on inquiry card.

UV Inspection Unit

New "Model B-50-H Mineralight" is an intense 100-watt long-wave (3660 A.u.) ultraviolet hand lamp op-

WHERE **SAFETY** COUNTS

YOUR INDUSTRIAL ALARM SYSTEM SHOULD BE . . .

AUTOMATICALLY and CONTINUOUSLY SELF-SUPERVISORY!*

ANOTHER "FIRST" BY SCAM

AND HERE IT IS!

Briefly, the new ACS* Circuit automatically signals the operator if the alarm system becomes inoperative due to failure of **any** component in the system itself! This self-policing, plus the compact "plug-in" design of the SCAM unit, provides immediate replacement while maintaining complete process supervision and protection.

And for the ultimate in simplicity, each SCAM "plug-in" may be used for either Normally OPEN or Normally CLOSED field conditions . . . thus allowing changes in the field from NO remote switch to NC remote switch.

Regardless of your control requirements, the new ACS* SCAM unit provides automatic supervision and flexibility of use in a **single** standardized unit. Plus the convenience of **immediate delivery from stock**, both during installation of the system and as requirements grow.

- **Use the same ACS* Unit for NO or NC Alarm Contacts.**
- **The basic ACS* Plug-in allows many operating sequences.**

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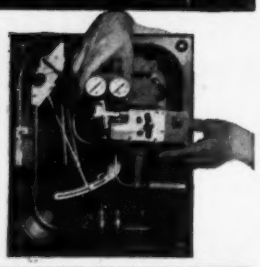
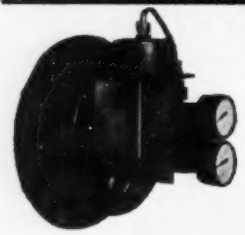


PENN air operated controllers and transmitters, piped with flexible tube, are readily removable for inspection or cleaning.

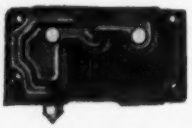
The "Worm" plate, a PENN exclusive, permits easy cleaning of air passages.

PNEUMATIC TRANSMITTER



Compact Pressure Gage Pneumatic Transmitter, takes no more space than 6" gage.

PENN'S Exclusive "WORM" PLATE



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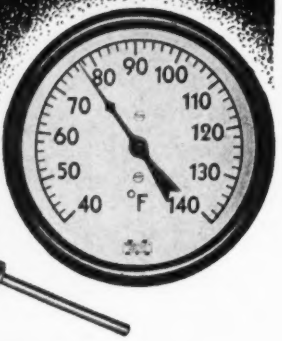
For further information circle **78** on inquiry card.

MARSHALLTOWN DIAL THERMOMETERS

New STAINLESS STEEL BULB AND NUT



THE COMPLETE LINE

Now furnished in stainless steel bulb and nut, Marshalltown dial thermometers are accurate, compact, durable instruments for the indication of liquid or gas temperatures. They are available in a variety of temperature ranges from minus 40° F. to plus 500° F. Actuation is positive, direct with full freedom — no gears or pinions. Available in sizes 2", 2½", 3½" and 4½".

WRITE TODAY FOR FULL DETAILS AND PRICES

Marshalltown Mfg. Co., Marshalltown, Iowa

For further information circle **79** on inquiry card.

NEW INSTRUMENTS

erating on 110-volt ac. It clamps rigidly to its non-tip base (containing transformer) and may be locked in any position. Radiation is harmless to eyes or skin.—*Ultra-Violet Products, Inc., 145 Pasadena Ave., South Pasadena, Calif.*

For further information circle **294** on inquiry card.

Air-type Height Gage

New "Airetest" indicator for critical dimensioning in toolroom work is a supersensitive air height gage which

indicates a movement of a few millionths. It consists of a pickup arm mounted on a beam actuating an air jet connected to a "Precisionaire" gage.—*The Sheffield Corp., Dayton 1, Ohio.*

For further information circle **295** on inquiry card.

Monochromatic Light Source

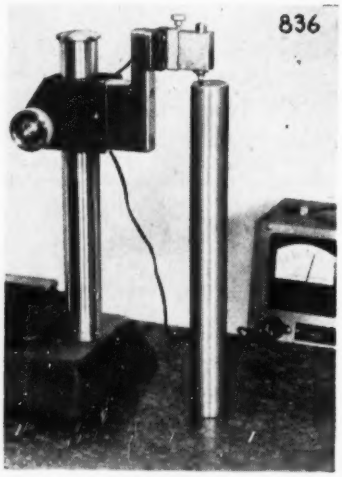
New "Monolight," largest commercial unit of its type, has 20-in. diam. high-intensity light source which can

be swung to illuminate 30 x 30-in. worktable, and 24-in. work-height capacity. Source is mercury-vapor lamp, providing maximal fringe-line definition and minimal glare.—*The DoALL Co., Des Plaines, Illinois*

For further information circle **296** on inquiry card.

Electronic Gage Attachment for Surface-plate Work

New "Par-Ac Adapter Bracket," for adapting maker's stand-and-anvil-type "Par-Ac Electronic Production

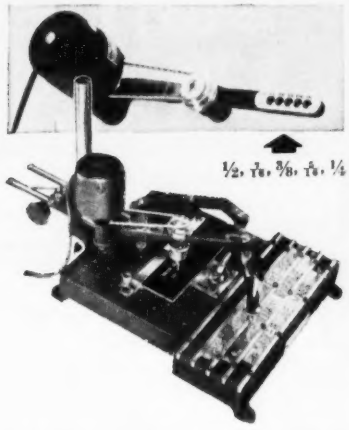


Gage" to a wide range of surface-plate work, is attached to back of saddle on "Par-Ac" stand, carries either "Par-Ac" gage head or an "Indi-Ac Electronic Indicator" head, as illustrated.—*Cleveland Instrument Co., 735 Carnegie Ave., Cleveland 15, Ohio.*

For further information circle **297** on inquiry card.

Engraving Machine

New model of maker's "Engraver" has five reduction ratios: ½, 7/16, ⅜, 5/16 and ¼, of which the second

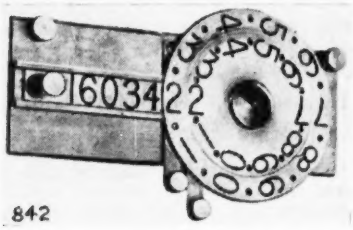


and fourth are additions to the three ratios of previous models.—*Green Instrument Co.*, 383 *Putnam Ave., Cambridge, Mass.*

For further information circle 298 on inquiry card.

Serial Numbering Dial for Engraving Machines

New "Serial Numbering Dial, Part #411-EM151" is faster method than



sliding new numeral templates into machine after each number has been engraved. It may be operated by unskilled labor.—*New Hermes Engraving Machine Corp.*, 13-19 *University Place, New York* 3, *N. Y.*

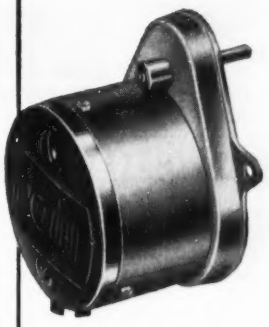
For further information circle 299 on inquiry card.

Diamond-lapping Compounds and Equipment Kit

New "Master Kit" is a complete micro-finish assortment: nine Spectrum grits, sizes 120 to 14,500 (three

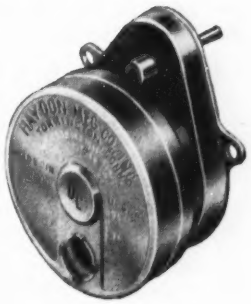
TIMING MOTORS *for* MILITARY APPLICATIONS

CONSTANT RESEARCH on improved timing motors enabled HAYDON* to introduce among other advanced timing components, its 6700 series 400 cycle timing motor. This is an hysteresis type synchronous timing motor, essentially two phase. It is furnished with capacitor for self starting operation on single phase. Variations in temperature, voltage and heat do not affect timing, which is as accurate as the frequency control.



The HAYDON 9200 Series D. C. motor for timing applications is designed for operation from 6 to 30 volts. It can be supplied uncalibrated for use with external resistance or calibrated with resistance type leads.

The 92[illegible]F Series HAYDON D. C. motor provides the more uniform torque and speed characteristics of a unit wound for 28 volts, and has an R. F. Interference filter. It offers superior performance over a wide temperature range as well as under load. The current and power drain is lower and no calibration is required.



The 1600 Series is the basic motor of the HAYDON line. This motor offers dependable performance, small size, total enclosure, operation in any position, controlled lubrication, simple assembly and a wide range of standard speeds from 60 to 1/60 rpm. Can be supplied to service specifications.

HAYDON Sales Engineers will gladly demonstrate that HAYDON motors will meet your requirements. Write details of your needs and we will be glad to help.

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For further information circle 80 on inquiry card.

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Used and endorsed by tool and die, electronic, machine, plastics, radio, electrical and instrument manufacturers. A *real* money saver.

Specify the Green Engraver for precision engraving on metal, plastics, wood, glass, hard rubber etc. . . . engraves panels, name plates, scales, dials, molds, lenses, instruments, instruction plates, directional signs . . . by simple tracing from master. *Routing, profiling and three dimentional modeling indicate its versatility.* Electric etching attachment available.

Special attachments and engineering service available for production work.

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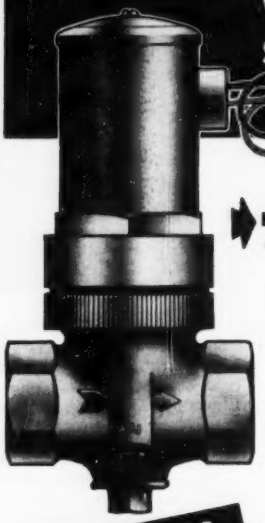
For further information circle **81** on inquiry card.

WHEN THE PRESSURE'S ON!

GOULD
SOLENOID VALVES



¼ TO 3" SIZES
WIDE PRESSURE RANGE

BUILT-IN: Manual Opening, and Adjustable Cushioning Adjustments

Guaranteed Water and Oil Proof Coils

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VELVETROL DL and D Valves incorporate new O-Ring bonnet seal.

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For further information circle **82** on inquiry card.

NEW INSTRUMENTS

other grit sizes available), in accordance with NBS specifications; 4-oz. bottle of diamond lapping oil; atomizer oil applicator; assortment of Spectrum micro laps; orangewood sticks, and assortment of felt-mounted points.—*Penn Scientific Products Co., 5941 Alma St., Philadelphia 24, Pa.*

For further information circle **300** on inquiry card.

ELECTRICAL INSTRUMENTS

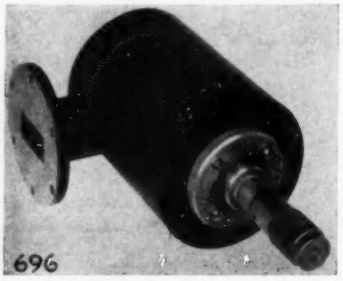
Multi-range Wattmeter

New "Model 110 Electronic Wattmeter," basically an amplifier driving the potential coil of a dynamometer wattmeter, has a range from 0.3 to 300 watts on six scales, with accessory shunts extending range to 9000 watts. Frequency response from 20 to 3000 cps. permits measurements at all power and aircraft frequencies with no need for corrections of any kind.—*Keithley Instruments, 3868 Carnegie Ave., Cleveland 15, Ohio.*

For further information circle **301** on inquiry card.

Microwave Equipment

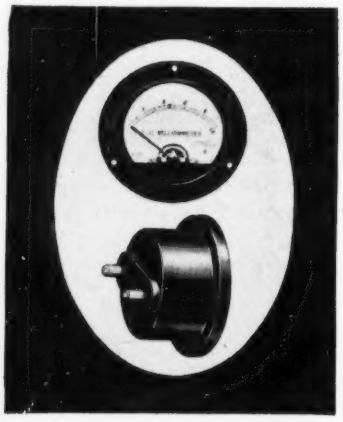
New waveguide instruments and components, originally designed to operate at high end of band allocated to RG-49/U waveguide (2x1-in.), have been redesigned to operate in RG-50/U (1.5x0.75 in.) waveguide between 5.3 and 6.5 kMc. Illustrated is a reaction-cavity wavemeter with an RG-50/U waveguide input similar to maker's standard wavemaster but for 5.3-kMc. frequency range: hermetically-sealed, nitrogen-filled, temperature compensated, etc.—*DeMornay-Bonardi Corp., 3223 Burton Ave., Burbank, Calif.*



For further information circle **302** on inquiry card.

Ruggedized Sealed Electrical Indicating Instruments

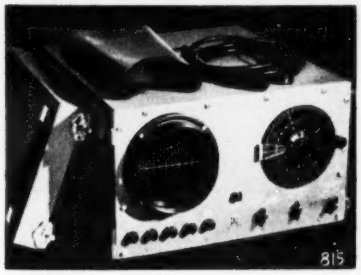
New shock-proof design of 2.5, 3.5 and 4.5 in. d-c. or rectifier a-c. instruments meets MIL-M-6A, MIL-M-10304 (Sig. C) specs. Movement is shock-mounted in low-temperature rubber compound and bonded to case, and does not flop around under vibration or shock. New type case has rear panel with screw type terminals to obviate need of soldered connections. Case design and neoprene gasket permit opening and resealing of factory-sealed case with simple tools.—*The Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*



For further information circle **303** on inquiry card.

Line-fault Locator

New "Model 124 Line Fault Analyzer" minimizes time, work and hazard of locating line faults; operates from



any powerhouse, transformer bank or substation to pinpoint shorts, grounds or open circuits at ranges from 0.5 to 200 miles; is direct-reading and simple to operate; can be attached quickly to any line, using regular carrier coupling capacitors.—*Sierra Electronics Corp., San Carlos 2, Calif.*

For further information circle **304** on inquiry card.

Phase Angle Meter

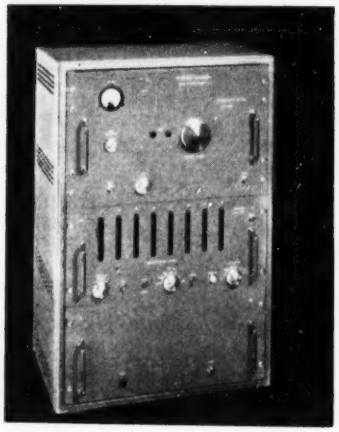
New "Model 100A Phasemeter" indicates phase angle between two alternating signals; covers angles between

0 and 180 degrees, lead or lag, in two expanded scale ranges, without ambiguity; is designed for frequency range of 2 cps. to 200 kc.; includes an electronically-regulated power supply.—*Deltron, Inc., P. O. Box 192, Glenside, Pa.*

For further information circle **305** on inquiry card.

0-42-Mc. Frequency Meter

New "Model 5570" frequency meter is said to be first direct-reading instrument capable of measuring fre-



Description: Model 5120 provides direct reading of elapsed time between any two events, in increments of one microsecond, to a maximum of 1 second. Accuracy is ± 1 microsecond, ± crystal stability (3 parts in 10^6). It consists of a power supply, a 1 megacycle crystal oscillator, an electronic gate with start-stop channels for external control, and six cascaded BERKELEY decimal counting units. The first event "pulse" opens gate, passing 1 megacycle time base signal to counting units. Second event "pulse" closes gate; elapsed time is displayed in microseconds. Input pulses may be either polarity; attenuators permit selection of optimum amplitude. Standard modifications are available to supply marker pulses from slowly changing wave forms to actuate start-stop channels, to extend range and accuracy by factor of 10, to extend total range to 1,000,000 seconds, or to permit use as an electronic counter.

applications: Simplicity of operation and ease of reading make the Model 5120 ideal for both production line and laboratory use for relay and switch timing, accurate measurements of viscosity, elasticity, low frequencies, rates of motion, timing of photographic components, duration of light flashes, and many other applications.

SPECIFICATIONS

RANGE: 3 microseconds to 1 second
ACCURACY: ± 1 microsecond, ± crystal stability (3 parts in 10^6).
POWER REQUIREMENTS: 117 v. (± 10%), 50-60 cycles, 175 watts.
INPUT SIGNALS:
START-STOP CHANNELS: Min. signal 5 v. peak; min. rate of change 20 v., either polarity.
PHOTO CHANNEL: 50 mv. peak sensitivity, direct coupled. 1, 10 and 100 attenuation range.
COUNTER INPUT: 1 v. peak sensitivity.
ACCESSORY SOCKET: Ground; 6.3 v. a.c., 2 a.; 250 v., 20 ma; + 100 v., 10 ma; − 105 v., 5 ma. external reset.
DIMENSIONS, NET WT.: 20¾" wide x 19" high x 15" deep; 110 lbs.
PRICE (F.O.B. RICHMOND): Model 5120, $995.

M-10

For complete information, please request Bulletin 605

Berkeley Scientific
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For further information circle **83** on inquiry card.

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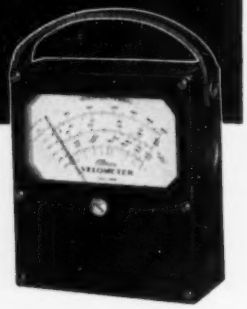
instantly... accurately... anywhere...



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Alnor Velometer, a precision-built, self-contained, portable instrument, gives you instant, *accurate* readings of air velocities anywhere—in plants, mines, mills or laboratories. Measures speed of air flow through ducts, grilles, furnaces, spray booths or in the open. This rugged instrument needs no special care or delicate handling—anyone can use it and get accurate readings. Needs no calculations or reference charts. Available in a wide variety of scale ranges, and with a full assortment of jets and fittings for every application. You'll want full details and prices, so write for Bulletin 2448-G, Illinois Testing Laboratories, Inc., Room 518, 420 No. La Salle St., Chicago 10, Ill.

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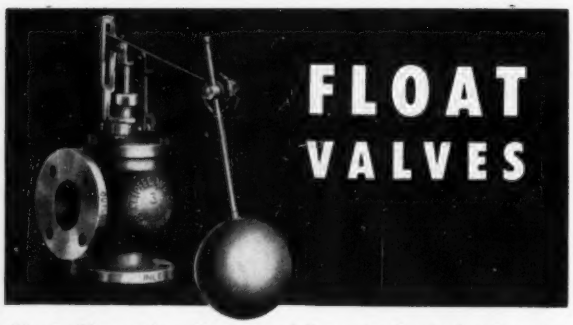
For further information circle **84** on inquiry card.



No. 77 illustrated — Single seated float valve for dead end service. Internal pilot control. 250 lbs. max. inlet pressure. Does the job of more complicated control valves at a much lower cost wherever tight closing float valves are required for make-up water control. Sizes 2" — 8". Other types. Get BULLETIN 349.

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K-139

Klipfel **VALVES, INC.** HAMILTON, OHIO

For further information circle **85** on inquiry card.

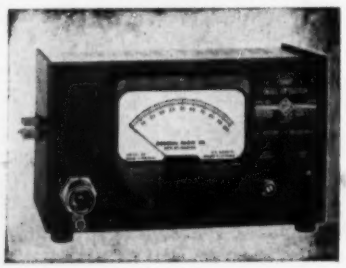
NEW INSTRUMENTS

quencies from 0 cps. to 42 Mc. Indicated frequency is displayed in digital form on eight banks of illuminated Lucite number panels. "Model 5570" consists of: (1) a high-speed "EPUT" (events-per-unit-time meter) and (2) a heterodyne unit. Frequencies of 2 Mc. and below are applied directly to "EPUT" section and are read on last six decade number panels. Frequencies from 2 to 42 Mc. are applied to heterodyne section; megacycle selector knob turned to proper harmonic and results read directly on eight decade number panels.—*Berkeley Scientific Div., Beckman Instruments, Inc., 2200 Wright Ave., Richmond, Calif.*

For further information circle **306** on inquiry card.

Null Detector

New "Type 1212-A Unit Null Detector," primarily a balance indicator for a-c. bridges, is useful as a sensitive wide-frequency-range voltage indicator: from 20 cps. to 5 Mc. An

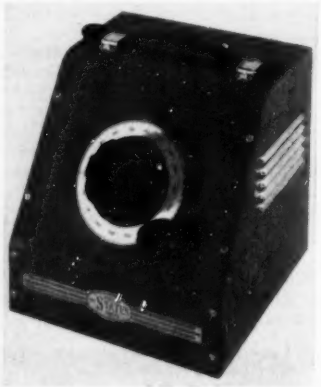


approximately logarithmic relationship between reading and input voltage gives an on-scale range of about 120 db. Full-scale deflection is about 100 volts but less than 40 microvolts deflects pointer by 1 percent of full-scale.—*General Radio Co., Cambridge 39, Mass.*

For further information circle **307** on inquiry card.

Phase Shifter

New "Type R-1/2" 50-amp. portable unit has been added to maker's phase shifter line. Every possible phase an-

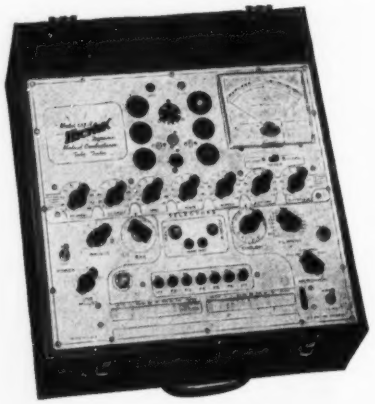


gle displacement can be obtained, as phase shifting is continuous. Graduated scale permits making small changes in angular position of rotor with precision.—*The States Company, Hartford, Conn.*

For further information circle **308** on inquiry card.

Tube Tester

New "Model 533AP" professional type tube tester for radio-TV and communication technicians is said to

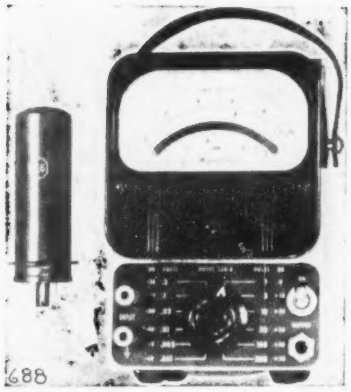


embody many new and outstanding features to increase accuracy and completeness of test on all tubes normally encountered in electronic equipment maintenance.—*The Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*

For further information circle **309** on inquiry card.

Extended-range Voltmeter

New "Model 520-A" miniature extended-range voltmeter weighs 6 lbs.; fits topcoat pocket; operates over frequency range 10 cps. to 2 Mc.;

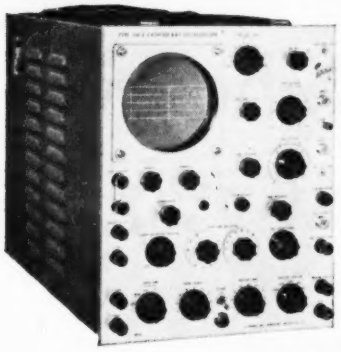


has full-scale sensitivity of 1 millivolt; ranges up to 300 volts, as well as decibel readings from minus 72 to plus 52; 4.5-in. mirror scale; rectifier of full-wave average type. An output connection permits unit to be used as a broadband amplifier with sensitivity adjustable in 10-db steps; this function does not interfere with voltmeter operation.—*Waveforms, Inc., 333 Sixth Ave., New York City.*

For further information circle **310** on inquiry card.

Cathode-ray Oscilloscope

New "Type 514-AD" portable (61-lb.) laboratory type oscilloscope has 6-cm. undistorted vertical deflection, new direct-coupled vertical amplifier,



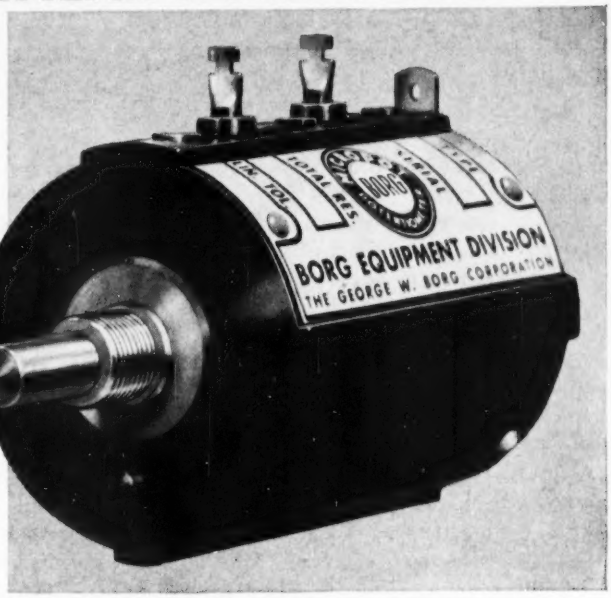
new flat-faced CRT, new variable-duty-cycle calibrator, new direct-coupled unblanking. Vertical amplifier bandwith dc. to 10 Mc. at 0.3 v/cm. to 100 v/cm. sensitivity, 2 cps. to 10 Mc. at 0.03 v/cm. to 100 v/cm. sensitivity, rise-time 0.04 usec., 0.25 usec. signal delay. Time base range 0.1 usec/cm. to 0.01 sec/cm.; improved 5x sweep magnifier; 3-kv. accelerating potential; all dc. voltages electronically regulated.—*Tektronix, Inc., P. O. Box 831, Portland 7, Ore.*

For further information circle **311** on inquiry card.

Synchro-test Amplifier

New "Model 105 Meter Matcher" power-frequency amplifier permits accurate tests of secondary voltage of synchros and other circuits requiring instrument current corrections. When used in conjunction with a voltmeter or wattmeter, it practically eliminates errors previously caused by instrument currents. Its input is connected to synchro, its output to voltmeter or wattmeter. Its input impedance

THE HIGH-PRECISION LINEAR POTENTIOMETER

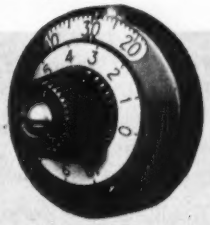


MICROPOT
precision ten-turn potentiometer

BORG MICROPOT TEN-TURN POTENTIOMETER: Built to fit the specifications of control system engineers and designers . . . constructed with Micro accuracy for precise voltage adjustments . . . featuring an assembly scientifically designed, machined, assembled and automatically machine tested for linearity of ±0.1% and 0.05%, zero-based. MICROPOTS ARE AVAILABLE IN 1.15 to 3 OHM and 30 to 250,000 OHM RANGES FOR IMMEDIATE SHIPMENT.

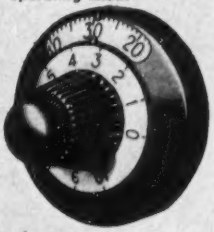
BORG MICRODIAL: Two concentrically mounted dials: one for counting increments of each turn and the other for counting turns . . . delivered completely assembled with dials synchronized. Outstanding features include smooth, uniform action . . . no backlash between incremental dial and potentiometer contact . . . less wear, only one moving part aside from the two dials . . . contact position indicated to an indexed accuracy of 1 part in 1,000.

MICROPOT—MICRODIAL CATALOG SENT PROMPTLY ON REQUEST



BORG MICRODIAL 746-A

A precision ten-turn indicating dial assembly. Has screw locking device on operating knob.



BORG MICRODIAL 746-B

Same as 746-A but has knurled locking screw mounted externally to operating knob.

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
Janesville • Wisconsin

For further information circle **86** on inquiry card.

Service . . . where and when you want it

PROMPT, experienced service is one of the most important plus values you get when you buy Honeywell instruments. An unequalled organization of trained specialists is always at your call at more than 110 offices in the United States and Canada. Offices are located in practically every large industrial city of the country . . . close to every major production center.

Trained Personnel

Honeywell service men are schooled not only in the theory of measurement and control, but also in the practical art of keeping good instruments in the best condition. Hand picked men begin this instrument education in an intensive training program in Honeywell factories. After graduation, they serve an apprenticeship in the field offices . . . while they learn still more about instrument maintenance from first-hand contact with plant problems. By the time a Honeywell man arrives at your plant on a call, he's a finished product worthy of the responsibility he bears, and capable of doing the kind of service job that you need . . . and that your Honeywell instruments deserve.

When trouble strikes, a wire or telephone call will bring a service man to your plant . . . often within a few hours. This assurance of prompt action means a lot to your production schedules. You'll never be left out on a limb because of delays in instrument maintenance.

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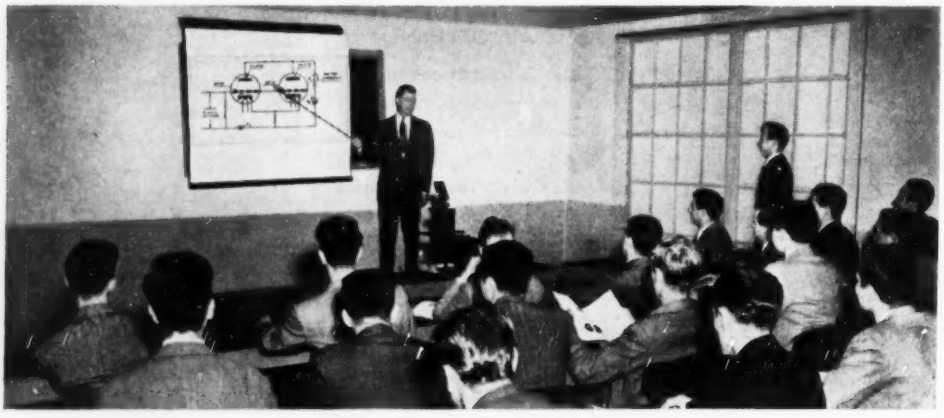
But why wait for emergencies? Preventive medicine works on instruments, too. And the prescription is simple . . . a Periodic Service Contract, which brings a Honeywell service man to your plant at regular intervals to inspect, clean and adjust any Honeywell instruments you have. The plan is economical . . . can save you many hours of lost production time. Your nearest Honeywell office will be glad to give you full details.

Wherever *rely on*



TRAINED TO SERVE: *In Honeywell's service school, students get a thorough grounding in instrument theory and practice. After graduation, they become part of the most extensive organization of its kind in the world . . . ready to serve you competently and promptly, whenever and wherever you need them.*

For further information circle 87 on inquiry card.

ROUNDING UP TEMPERATURES, *this ElectroniK recorder keeps operators in a New England station informed on heat balance conditions at eight selected points in the steam cycle.*

measurement counts...
ElectroniK recorders

FOR ALL the vital measurements that are essential to power plant supervision, you'll get the most in performance with *ElectroniK* recorders. They have every feature that power engineers demand:

They're versatile: the same basic, industry-proved instrument is supplied for measuring temperature, frequency, power, flow, pressure, pH and conductivity. Single and multi-point models are available in a choice of printing speeds and chart speeds . . . readily equipped to operate signals and alarms.

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Behind these instruments stands the largest service organization of its kind, operating from more than 90 offices strategically located in the U. S., Canada, and throughout the world. Ask your local engineering representative for full facts . . . he is as near as your phone.

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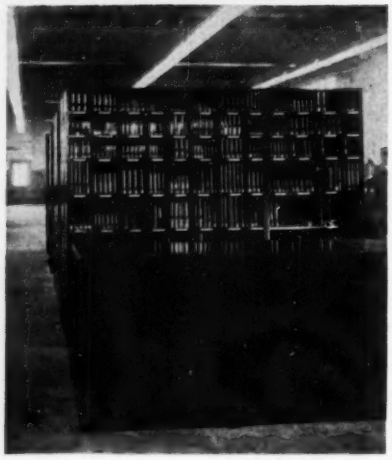

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For further information circle **88** on inquiry card.

Measurements Corporation
MODEL 82

STANDARD SIGNAL GENERATOR

20 Cycles to 50 Mc.

FREQUENCY RANGE: 20 cycles to 200 Kc. in four ranges. 80 Kc. to 50 Mc. in seven ranges.

OUTPUT VOLTAGE: 0 to 50 volts across 7500 ohms from 20 cycles to 200 Kc. 0.1 microvolt to 1 volt across 50 ohms over most of range from 80 Kc. to 50 Mc.

MODULATION: Continuously variable 0 to 50% from 20 cycles to 20 Kc.

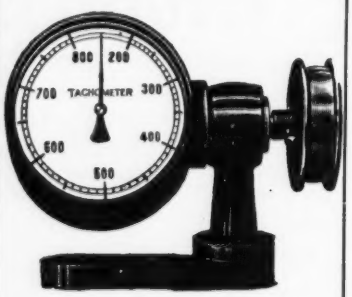
POWER SUPPLY: 117 volts, 50/60 cycles. 75 watts.

DIMENSIONS: 15" x 19" x 12". Weight, 50 lbs.

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY

For further information circle **89** on inquiry card.

Amthor



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Amthor Testing Instrument Co., Inc.
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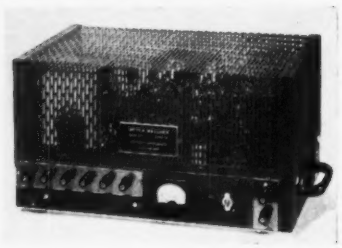
For further information circle **90** on inquiry card.

NEW INSTRUMENTS

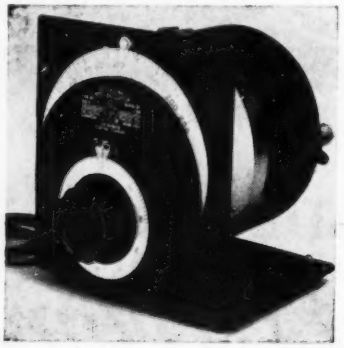


requires less than 150 microamperes from test circuit; its output provides 0.05 to 0.07 ampere which most accurate dynamometer instruments require for full-scale deflection. Its overall accuracy is such that less than 0.15 percent error is added to measurements. Many uses other than synchro testing will suggest themselves. —*Keithley Instruments, 3868 Carnegie Ave., Cleveland 15, Ohio.*

For further information circle **312** on inquiry card.

Megacycle Oscillator

New "Type 1215-A Unit Oscillator" produces frequencies from 50 to 250 Mc. over a single continuous range.



Frequency is read directly from a 6-inch dial with a calibrated slow-motion drive. At least 80 milliwatts can be delivered at any frequency into a 50-ohm load.—*General Radio Co., Cambridge 39, Mass.*

For further information circle **313** on inquiry card.

Circuit Tester

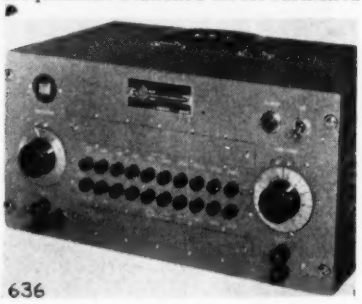
New "Desco Circuitracer" weighs 2.5 oz.; is a 3-in-one tester, used to trace circuits for continuity and pres-

ence of dc or ac voltage; to test live circuits as low as 2 volts or as high as 600 volts, or dead circuits and devices; to locate grounds, opens or shorts in dead or live circuits.—*Delta Electrical Specialty Co., 1456 E. Walnut St., Pasadena, Calif.*

For further information circle **314** on inquiry card.

Audio Oscillator

New "Model TO-100" audio oscillator, especially useful for checking FM/FM telemetering sub-carrier equipment, has twenty fixed center-frequencies. Standard model furnished

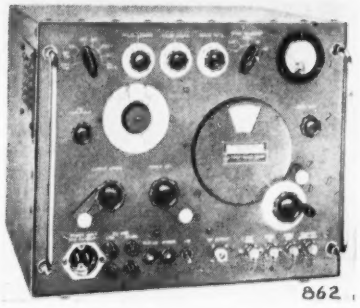


with FM/FM telemetering frequencies from 400 to 70,000 cps. (others between 200 and 100,000 cps. on special order). Each frequency is selected by a push-button and can be continuously varied plus or minus 10 percent by means of a calibrated control. Each frequency is accurate to 1 percent and an independent sub-panel control is available for each frequency for more accurate setting if necessary.—*Dep't IA, Teletronics Laboratory, Inc., 54 Kinkel St., Westbury, N. Y.*

For further information circle **315** on inquiry card.

SHF Signal Generator

New "Model 618B" signal generator, for radio-relay, radar, TV-carrier systems, etc., involving super high frequencies, has reflex klystron



oscillator for frequency generation; continuous range of 3,800 to 7,600 Mc.; frequency and voltage directly set and read; dial tuning tracked automatically and no voltage adjustment required during operation. Instrument may be internally or externally pulse modulated. Repetition rate continuously variable from 40 to 4,000 pps.; pulse width variable from 0.5 to 10 usec.—*Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif.*

For further information circle **316** on inquiry card.

Inverter-amplifier

New "Model 305 Amplifier" for use with numerous types of pickups, employs a-c. amplification or low level d-c. by means of an inverter consisting of a pair of matched germanium diodes set up in a bridge. Bridge balance is effected by a ten-turn "Helipot." D.c. applied to bridge results in unbalance and excitation frequency (50 kc.) appears at grid of first am-

DEPENDABLE
1/8 MICRO-SECOND TIMING

WHEN YOU CAN'T AFFORD TO MISS

IN MEASURING:
- VELOCITY
- ACCELERATION
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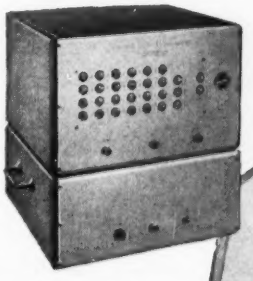
Potter INSTRUMENT COMPANY, INC.

8 MEGACYCLE COUNTER-CHRONOGRAPH

DIVIDES 1 SECOND INTO 8,000,000 PARTS



GREATER ACCURACY
The use of an 8 megacycle crystal time base provides the highest resolution of time measurement available in direct reading instruments.

COMPLETE DEPENDABILITY
To assure the highest degree of dependability, a straightforward 3-stage binary counter is used at the 8 megacycle frequency, permitting the conservative use of decade counters at the lower frequencies.

DIRECT READING
Digital registration is used to indicate time from 1 microsecond to 1 second by means of 6 Potter decades. Fractional parts of a microsecond are read from a 3-stage binary counter which indicates in steps of ⅛ microsecond.

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Ten years of service in proving grounds and research centers give conclusive evidence that the simplified circuitry inherent in the Potter Counter-Chronographs provides the maximum reliability for critical timing applications.

WIDE APPLICATION
There is a Potter Counter-Chronograph made for your specific application. High-speed digital recorders are available for permanent recording of measurements at rates up to 150 per second.

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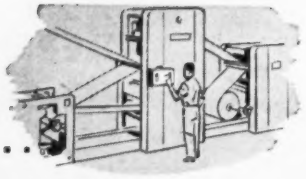
For further information circle **91** on inquiry card.

For precise checking
of temperature, humidity . . .



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If your plant maintains temperature and humidity control, the Bendix-Friez Hygro-Thermograph offers you a graphic, scientific, year-'round check on the efficiency of that control. Hygro-Thermograph actually protects your air conditioning investment by giving you *a precise record* which shows instantly any variation in temperature or relative humidity. Producer of the world's finest weather instruments, Bendix-Friez is rendering constantly increasing service to industry. Find out how we can help you.

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For further information circle 92 on inquiry card.

THE EDER LIGHT

SPEEDS INSPECTION OF

Hard-to-get-at places

Delivers light where you need it . . . through a hole, around a corner, or in a deep groove. Adjusts to any angle. Glare-free. Fits in the palm of your hand.

NEW ATTACHMENTS

10 time magnifying attachment fits the Eder-Lite. Clear, no distortion view. For checking microscopic detail.

New slender tube with lamp on end only 1/8" total diameter. Fits through tiny hole or in crevice.

Right angle mirror attachment ideal for viewing behind shoulders or ledges.

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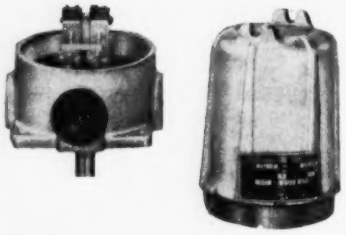
2293 N. Clybourn St. (Dept. I) Chicago 14, Ill.

For further information circle 93 on inquiry card.

Explosion and Waterproof Controls



The Burling Model VD-2X above is an explosion proof, two switch temperature control. Each switch operates an independent circuit and may be set for different temperatures.

Other Burling Features

- Range from −300°F to +1800°F
- Electric or Pneumatic
- One, two or three Micro Switches
- Differential Expansion of Solids
- No liquids—No gases
- For controls, safety alarms, cut-outs.

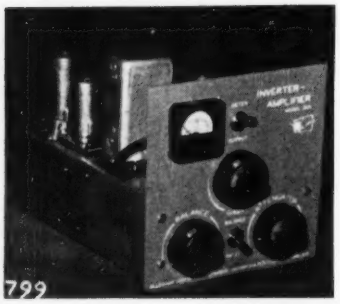
Send for Catalog G-18

Burling Instrument Co.
9 Vose Avenue
South Orange, New Jersey

Burling TEMPERATURE Controls

For further information circle 94 on inquiry card.

NEW INSTRUMENTS

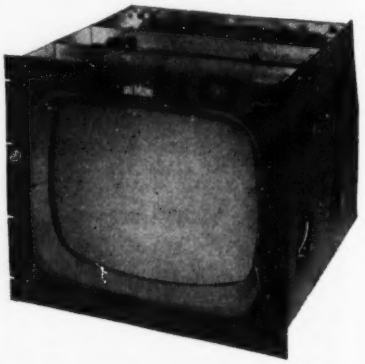


plifier tube. Drift is below 100 microvolts per hour after warm-up. 50 kc. signal passes through two tuned stages and is finally demodulated. Demodulated signal may be used to drive a varity of galvanometers. Overload protection is provided by an OB2.—*Allegany Instrument Co.*, 1000 *Oldtown Rd., Cumberland, Md.*

For further information circle 317 on inquiry card.

Picture Monitor

New "Type 5281-B" 17-in. picture monitor may be operated on either composite-picture signal or separate-

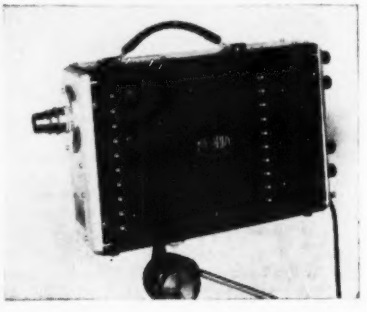


sync signal; will detect sync generator faults not noticed on monitors of triggered sweep design.—*Television Transmitter Div., Allen B. Du Mont Laboratories, Inc., Clifton, N. J.*

For further information circle 318 on inquiry card.

Miniature TV Camera Unit

New "Tel-Eye" closed-circuit TV camera unit has all associated power, synchronizing, RF, monitoring and output equipment, plus camera itself, contained in small camera head (size of portable typewriter case). Will

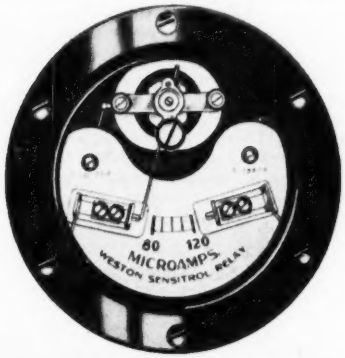


feed multiple TV receivers up to 2,000 feet; is applicable to banks, industrial plants, traffic control, etc.—*Television Transmitter Div., Allen B. Du Mont Labs, Inc., Clifton, N. J.*

For further information circle 319 on inquiry card.

Sealed and Self-shielded Magnetic-contact Relay

New "Model 723" of maker's "Sensitrol" (magnetic contact) type relay is sealed against moisture; incorporates a newly-designed self-shielded core magnet mechanism and a built-in solenoid-release device; is available with double magnetic contacts, or with single magnetic contacts to make contact on either increasing or decreasing values. Sensitivities as high as 2-0-2 microamperes are available; a-c. and d-c. voltage ranges can be supplied self-contained up to 500 volts. Contact capacity of parallel magnetic contacts is 100 ma. at 120 volts a.c. or d.c.—*Weston Electrical Instrument Corp., Newark, N. J.*



For further information circle 320 on inquiry card.

Dual-purpose HF Test Set

New "Model AET-117 American Wavemeter" is designed for measuring operating frequency and making relative power measurements of microwave transmitters or signal sources; is applicable to pulsed transmitters as well as cw. systems; oper-

PLANT...

PRODUCT...

PROCESS

analyzed-controlled by Librascope...

Whatever the function, Librascope *simplified* Computers and Controls are introducing new efficiency . . . in plant, product and process control of continuous or batch production. *Whatever your specific need . . .* Librascope, Inc., designers and manufacturers of both Analog and Digital Computers and Controls, can give you functionally designed equipment packaged to give the utmost in reliability and performance.

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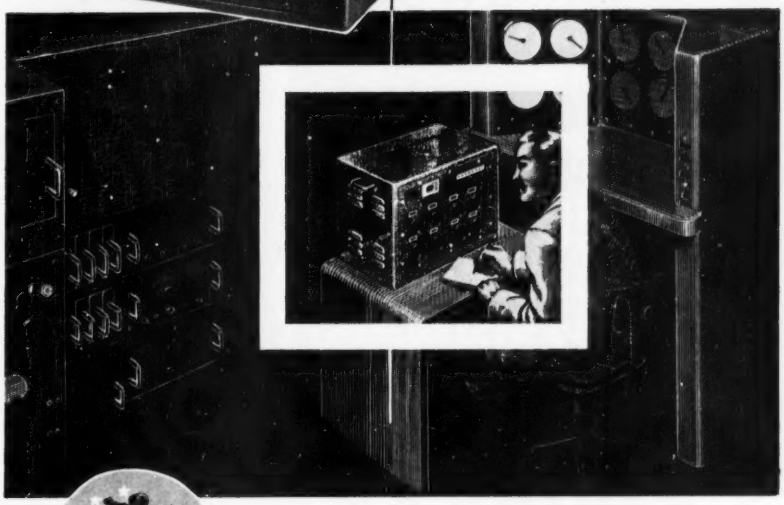
The Simultaneous Equation Solver,

an *integral* part of Baird Associates, Inc. new spectograph, is a *simplified* analog computer that resolves the machine's complex data output.



If you desire the challenge of advanced design fields, write to Dick Hastings, Director of Personnel.

Analog and Digital Computers, Input-Output Devices, and Components

LIBRASCOPE INCORPORATED

1607 FLOWER STREET, GLENDALE 1, CALIFORNIA

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

For further information circle 95 on inquiry card.

VICTOREEN'S IMPROVED THYAC SURVEY METER
MODEL 389 C

One more example of Victoreen's 25 years of scientific know-how and engineering leadership.

SPECIFICATIONS

Radiation: Beta, gamma and cosmic

Indication: 3" meter and detachable headset

Sensitivity: 800, 8000, 80,000 counts per minute or 0.2, 2.0, 20.0 mr/hour, from Radium 0.5 millimeters of Platinum, using the 1885 Thyrode

Accuracy: ± 10%

Battery Life: 110 hours at 8 hours per day

Dimensions: 9⅞" long by 4 11/16" wide by 7¼" high

Weight: 5½ pounds

Significant new features have been engineered into this precision-built Geiger tube type of survey ratemeter for monitoring low-intensity beta or gamma radiation.

- Improved case design. Laminated plastic, tough, lightweight, ready for rugged service.
- Better gasketing guarantees splashproof operation.
- An "ON-OFF" pilot light gives visual indication that the unit is operating.
- Greater reliability in power supply. High voltage and low voltage supplies are regulated against battery variation.
- Scintillation probes may now be adapted to the improved Thyac.

Plus: Finger-tip operation . . . sliding shield on the probe . . . broadened versatility which makes the instrument adaptable for many applications.

Write today for Victoreen's Model 389 C Thyac catalogue sheet.

The Victoreen Instrument Co
5806 HOUGH AVENUE • CLEVELAND, OHIO

For further information circle **96** on inquiry card.

TANK-O-METER
FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY

HYDROSTATIC GAUGES
FOR ALL PURPOSES

PRESSURE • VACUUM • DRAFT
DEPTH & ABSOLUTE PRESSURE
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For further information circle **97** on inquiry card.

Orifice Plates
FOR IMMEDIATE DELIVERY
The most accurate plates commercially obtainable. Stocked in a wide range of sizes, types and materials for all measurement conditions.
Also manufactured to special specifications.
Write for descriptive Bulletin-G
DANIEL ORIFICE FITTING CO.
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5405 Clinton Dr. Houston 20, Texas

For further information circle **98** on inquiry card.

NEW INSTRUMENTS

ating range is 2400 to 3400 Mc. (available in other frequency ranges for special applications). Novel feature is combining of either transmission or reaction type measurements in one instrument, obviating need for two instruments.—*Electronics Div., American Encaustic Tiling Co., Inc., Lansdale, Penna.*

For further information circle **321** on inquiry card.

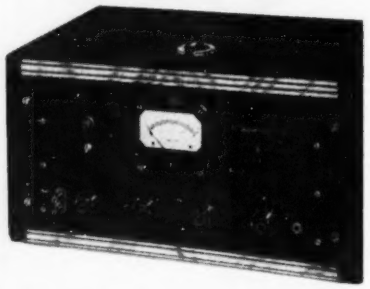
Audio Control

New "Type 8514-B" straight-line slide-wire mixer control uses ladder circuit with 6-db insertion loss, is available in 500-600 ohm models. Knobs provide finger-tip operation similar to typewriter keys.—*Cinema Engineering Co., Burbank, Calif.*

For further information circle **322** on inquiry card.

Wow Meter

New "Model 115-RA" wow meter for measuring variations and fluctuations of speed of phonograph turn-

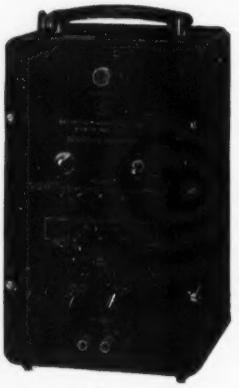


tables and other reproducing equipment, can be used not only in laboratories, but also by unskilled personnel on production lines.—*Furst Electronics, 3322 W. Lawrence Ave., Chicago 25, Ill.*

For further information circle **323** on inquiry card.

Sensitive Inverter

New "Model 700 Sensitive Inverter," in combination with a suitable 60-cps. voltage-sensitive device, makes



possible (1) accurate measurement of d-c. potentials as low as 10 microvolts, and (2) detection of d-c. potentials as low as 1 microvolt while presenting to the source a resistance not less than 10 megohms. Built-in calibrator minimizes errors

caused by a companion instrument or by departure of line frequency and voltage from nominal values. Power sensitivity is 10^{-19} watt.—*Ballantine Laboratories, Inc., Boonton, N. J.*

For further information circle **324** on inquiry card.

Insulation Tester

New "TAKK" high-voltage d-c. insulation test unit detects insulation weakness well before breakdown; does not impair value of insulation; is manufactured in four ranges: 15, 30, 45 and 75 kv.—*The John Hewson Co., 106 Water St., New York 5, N. Y.*

For further information circle **325** on inquiry card.

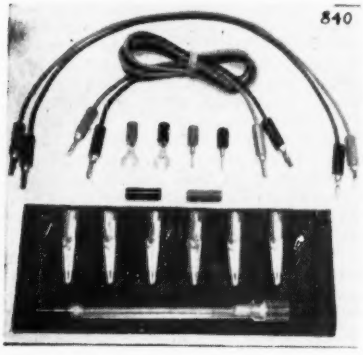
Variable Speaker Crossover

New "214-X8 Variable Speaker Crossover" permits speaker "woofers" and "tweeters" to operate under best conditions of speaker damping, relative output balance, and without undesirable effects of *L-C* crossover networks. Two controls: one for continuous adjustment of crossover frequency from 175 to 3000 cps.; other for continuous adjustment of acoustical balance between "woofer" and "tweeter." —*H. H. Scott, Inc., 385 Putnam Ave., Cambridge 39, Mass.*

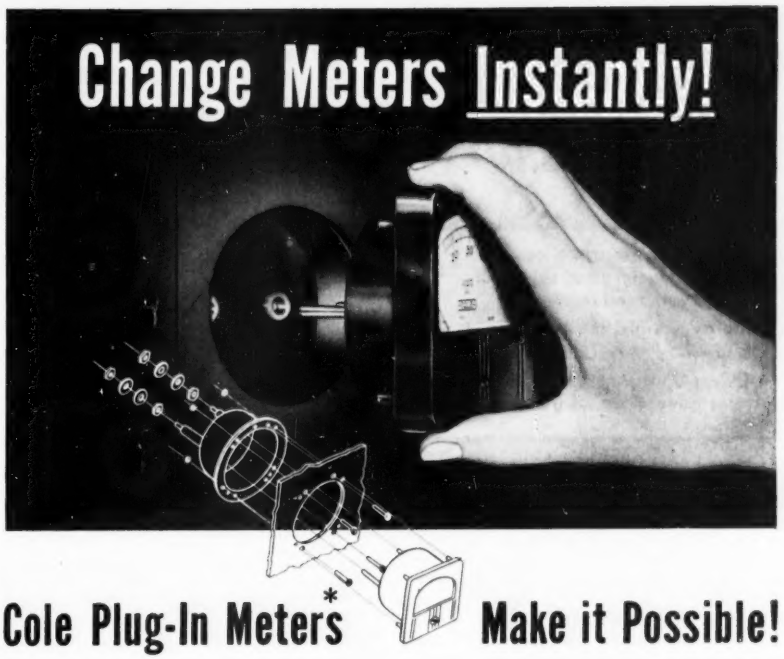
For further information circle **326** on inquiry card.

Test Leads

New "Universal Test Lead Set" comprises both jumper and probe types for quick interconnection between all types of electronic and electrical equipment; to pin jacks, banana jacks, terminal posts, etc. Feature is hollow polystyrene plug-in type probe inside which isolation components can be conveniently inserted. Alligator



Change Meters Instantly!



Cole Plug-In Meters* Make it Possible!

You can change or replace meters in five seconds in your production line or control panel. Eliminate down time and dismantling. Simply pull out one meter and push in the other. No special tools are required.

Only -COLE- Plug-In Meters give you this time- and money-saving convenience, plus the following:

1. Availability in all ranges. You specify it; we can supply it.
2. -COLE- engineering consultation service. Our years of custom-building can aid in your meter problems.
3. Two sizes to choose from: 3-inch and 4-inch. The 3-inch is available in round or rectangular cases. The 4-inch is available in a rectangular case.

IN PRODUCTION LINE TEST STATIONS – Change meters to accommodate changes in specifications without fuss or delay. Give your production line a new flexibility. "Go and No-Go" dials fairly shout to the inexperienced operator. They eliminate guesswork and errors.

IN LABORATORY AND FIELD TEST UNITS – Meters are the parts most frequently damaged in these installations. With Plug-In Meters, replacement takes practically zero time.

IN CONTROL PANELS – Even the very finest meters may go wrong occasionally. Replacement in most cases requires a substantial shutdown period and the services of an electrician and an assistant. With Plug-In Meters, replacement time can be reduced to five seconds. And anyone can make the change.

To take advantage of this new convenience in metering, you need only install -COLE- Receptacles in your present panel or control system. Then you can plug in ammeters or voltmeters in any ranges required.

For 24 years -COLE- has manufactured a complete line of highest quality custom-made testing devices. Besides their efficiency and convenience -COLE- Plug-In Meters incorporate all of the high accuracy and rugged construction of the finest meters.

-COLE- takes pride in its proved ability to deliver special-order high-quality instruments, whether of the plug-in type or not, with a speed that will surprise you. Years of custom manufacture have geared our plant to meet customer specifications on short notice. All work, including dial marking, is done under one roof.

Fill in and mail the coupon for quick information on -COLE- Plug-In Meters.

-COLE- *Instrument Company*

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Yes, I want more information on -COLE- Plug-In Meters. A-35

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*PATENT PENDING 51

For further information circle **99** on inquiry card.

QX Checker TYPE 110-A

A production testing instrument with laboratory accuracy under factory conditions

- **Rapid and accurate comparison of inductors and capacitors to known standards.**
- **Sturdy, simple, easily operated by factory personnel.**
- **Offers quick comparison between supplier and user.**

COIL TESTING

Coils are compared to a standard coil and the relative Q of the tested coil is read directly in percentage relation to the standard coil. The dial of the vernier condenser employed indicates the difference in inductance between the standard coil and the coils under test.

CONDENSER TESTING

The difference between capacitance of test condensers and standard condensers is indicated in mmf. by using an accessory coil 112-A22. Condenser losses are indicated on the meter on the instrument.

SPECIFICATIONS

OSCILLATOR FREQUENCY RANGE: 100 kc to 25 mc in six ranges using plug-in accessory inductors.

ACCURACY OF FREQUENCY CALIBRATION: Aproximately ± 3%.

RANGE OF COIL CHECKS: 1 microhenry to 10 millihenries.

ACCURACY OF COIL CHECKS: For Q = 100 or more and L above 10 mh; ± 0.2%.

RANGE OF CONDENSER CHECKS: 2 mmf to 1000 mmf.

INDICATING SYSTEM: Large diameter Q indicating meter with expanded 3½ inch scale. Double range 5 inch vernier condenser scale ± 5 and ± 50 mmf.

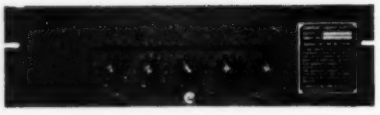
VOLTMETER: Stable self-contained Q voltmeter practically independent of normal line voltage fluctuations.

POWER SUPPLY: 100-125 or 200-250 volt 50-60 cps at approximately 50 watts.

Write for further information

BOONTON RADIO Corporation
BOONTON·N·J·U·S·A

For further information circle 100 on inquiry card.



RACK MOUNTING MODELS

105-125 V, 60C INPUT

OUTPUT CURRENT MAY BE SET AT ANY VALUE BETWEEN 0.2 AND 100 M.A. D.C. INCLUSIVE.

AS LOAD VOLTAGE VARIES BETWEEN 0-150 V. MODEL 2A-R IS CONSTANT WITHIN 1%. MODEL 2B-R WITHIN 0.1%.

ELECTRONICALLY REGULATED

D.C. CONSTANT CURRENT POWER SUPPLIES

OUTPUT CURRENT IS HELD CONSTANT AS LOAD VARIES

OTHER MODELS AVAILABLE
WRITE DEPT. 103 FOR LITERATURE

ASSOCIATED SPECIALTIES CO.
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OREFIELD, PENNSYLVANIA

For further information circle 101 on inquiry card.

INSTRUMENT MECHANIC—Should have experience with pneumatic, electronic, and electrical recording and controlling instruments, be familiar with calibration, installation and maintenance of said equipment. Instrument experience in pulp and paper mill preferred. Box 237, Instruments Publishing Co., 921 Ridge Ave., Pittsburgh 12, Penna.

For further information circle 102 on inquiry card.

Wanted

Industrial Instrument Mechanics. Must be experienced in the manufacture of Dial and Recording thermometers. Air, electric and self-operating Controllers, with mercury, vapor and liquid filled systems. Permanent and good pay for men who can get out the work.

Scientific Instrument Company
1041 Second Avenue
Detroit 26, Michigan

For further information circle 103 on inquiry card.

NEW INSTRUMENTS

clips are supplied with vinyl plastic sleeving. Individual components can be supplied.—*Air-O-Tronics, Box* 31, *Lancaster, Calif.*

For further information circle 327 on inquiry card.

D-c. Power Supplies

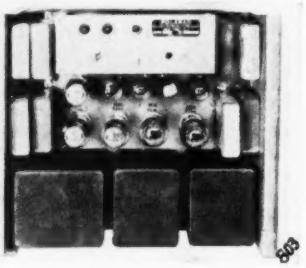
New d-c. power supplies maintain load current constant as load impedance changes or line voltage varies.

One model may be set at from 0.2 to 50 ma.; another covers 0.2 to 100 ma. Separate models are available for 1 percent and 0.1 percent accuracy. —*Associated Specialties Co.,* 1751 *Main St., Orefield, Penna.*

For further information circle 328 on inquiry card.

D-c. Power Supply

New "Model PT-110" electronically regulated power supply has output voltage adjustable from 400 to 450



volts at load currents to 325 ma. Regulation is better than 0.2 percent and ripple less than 8 mv. Centering current return available for TV; also a bias supply, negative 150 volts, 10 ma. —*Polarad Electronics Corp.,* 100 *Metropolitan Ave., Brooklyn* 11, *N. Y.*

For further information circle 329 on inquiry card.

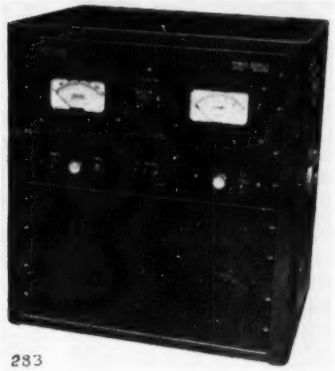
Voltage Stabilizers

New voltage stabilizers regulate output voltage for line voltage fluctuation as well as for frequency change; have new magnetic amplifier control which produces a nearly pure sine wave without special filters and is said to have better no-load to full-load regulation, lower temperature rise of components, higher efficiency at full load, longer life expectancy and lower maintenance, than electronic control. Unit will operate in temperature range of −10 C. to 60 C.; can be heavily overloaded without damage. First model of the new line operates on an input of 115 volts plus or minus 10 percent, 58 to 62 cycles, single phase, and provides an output of 115 volts, 2000 va. It can stabilize any fixed load to 0.5 percent for any line change and to 1 percent for frequency change.—*Equipment Sales Div., Raytheon Mfg. Co., Waltham* 54, *Mass.*

For further information circle 330 on inquiry card.

Regulated Power Supply

New "Model 3200" has low-voltage supply continuously variable from 1 to 13 volts and delivers from 0 to



283

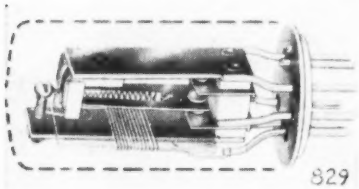
10 amperes continuous duty. Output voltage variation is less than 0.5 percent for line fluctuation from 105 to 125 volts and no-load to full-load. Ripple voltage is less than 10 millivolts.—*Kepco Labs*, 131-38 *Sanford Ave., Flushing* 55, *N. Y.*

For further information circle 331 on inquiry card.

ELECTROMECHANICAL COMPONENTS

Thermal Time-delay Relay

New "Snapper" s-p. d-t. 3-watt (max.) gas-filled thermal time-delay relay has positive snap action. Design



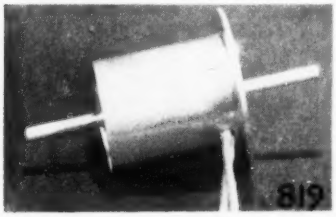
829

eliminates chattering. Voltages: 6.3, 26.5, 115 or as required, a.c. or d.c. Units operate in any position.—*Eureka Television and Tube Corp.*, 69 *Fifth Ave., Hawthorne, N. J.*

For further information circle 332 on inquiry card.

Mechanical-electrical Two-function Switch

New "Double-acting Mechanical-Electrical Switch" can perform two operations at one time. Mechanical operating part is a shaft, cable or wire passing through switch: movement may be rotation, translation or combination of both. Several cables or shafts may go through switch, each in turn operating it. Example of double duty: in liquid-level control, simul-



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The Gaertner

TOOLMAKERS' MICROSCOPE

For use wherever precision measurements are required in shop inspection or layout procedures.

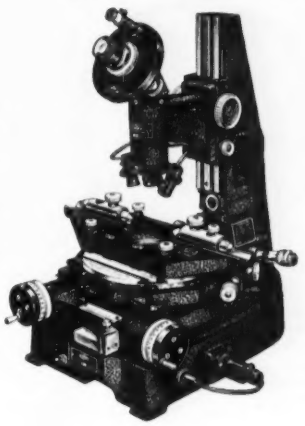
INCH OR METRIC UNITS

Coordinate Measurements
Left to Right.....100 mm or 4 inches
Front to Rear..... 50 mm or 2 inches

Direct Reading to..0.002 mm or 0.0001 inch

Angular Measurements

Stage Range.....	360°
Reading with Vernier.....	1 min.
Protractor Circle Range.....	360°
Reading with Vernier.....	1 min.
Magnification	30X
Microscope Column Tilt	±8°



- **Detects errors in cutting tools.**
- **Checks threads and thread gages.**
- **Measures critical dimensions on machine and instrument parts.**
- **Adaptable to flat work, round work, odd shapes.**

A completely illustrated booklet presenting detailed information on all models and accessories and suggesting applications.

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For further information circle 104 on inquiry card.

ENGINEER--INSTRUMENT

Experienced in design of panel instruments for airborne military use. Must be familiar with design criteria of all spring-return type instruments including D'Arsonval, ratiometer, drag-cup, and long-scale movements. Proven cleverness of design accepted in lieu of long experience in field.

Send resume to Miss Catherine Ayers
AVIATION ENGINEERING CORPORATION
34-56 58 St., Woodside, L.I., N. Y.

For further information circle 105 on inquiry card.

PALMER

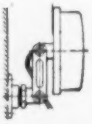
MERCURY ACTUATED

Dial Thermometers now in three types to suit any requirements

Full 4½" dial face. Stem can be placed at any angle and case can be rotated to any readable position.

1 **Rigid Stem Dial Thermometer** tapered bulb, interchangeable with standard industrial thermometer separable socket. (As illustrated above.)

2 **Wall Mounted Dial Thermometer** with flexible connecting armor. Case adjustable to easy reading position.



3 **Flush Mounted Dial Thermometer** for panel mounting with flexible connecting armor.

All three types have a full 4½" dial face.

for accuracy: Mercury actuated . . . Fully Compensated by Invar Compensaton. Guaranteed Accurate 1 scale division.

for angularity: Can be adjusted to most readable position at any angle desired.

for readability: Bold Black Numbers . . . 11" of scale Reading Dial face can always be placed in easiest readable position.

for interchangeability: Always specify "PALMER" Separable sockets as they are interchangeable for Dial or Industrial type Thermometers.

Send for Bulletin 51-129 for details on the New Palmer Dial Thermometer.

PALMER

THERMOMETERS, INC.

Norwood Ave., Cincinnati 12, Ohio

Mfrs. of Industrial Laboratory Recording and Dial Thermometers

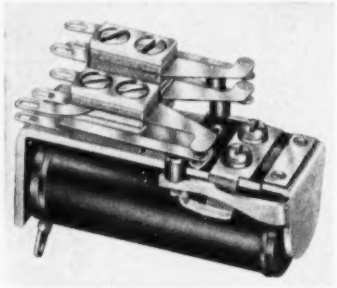
For further information circle **106** on inquiry card.

taneous electric control of pump motor and mechanical operation of a valve. Illustrated model is 1.87 in. long, weighs 2.5 oz.—*Beacon Engineering & Research Co., P. O. Box 6302, Washington, D.C.*

For further information circle **333** on inquiry card.

Telephone Type Relay

New "Type T-J" fast-action telephone type relay features long-core design which gives it sensitivity and makes it suitable for use in complex

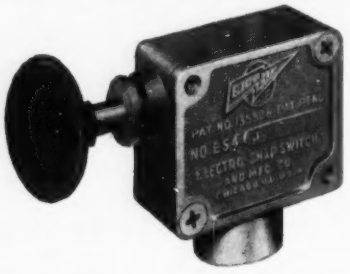


circuits involving pull-in and drop-out time delay. Available contact combinations up to 4-p.d-t. or 6-p.s-t.; standard contacts fine silver, palladium or other materials can be supplied; units can be supplied hermetically sealed to meet military specifications.—*Comar Electric Co., 3349 W. Addison St., Chicago 18, Ill.*

For further information circle **331** on inquiry card.

Limit Switch

New "Type ES4-J" 10-amp. industrial limit switch makes possible inexpensive circuit controls by mini-

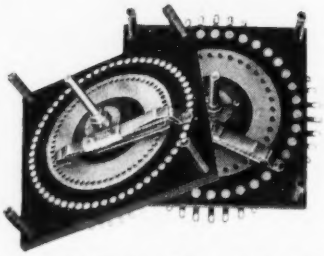


mizing need for relays in sequencing or interlock; has 1.75-in. diameter plastic button to make switch easy to operate manually. Also recommended for safety purposes: example, on a punch press, a worker must depress both switches with his hands before press will operate. Units available with either constant or one-way momentary contact action.—*Electro-Snap Switch and Mfg. Co., 4218 W. Lake St., Chicago 24, Ill.*

For further information circle **335** on inquiry card.

Heavy-duty Rotary Switches

New "Type 10061-S" (60-position) and "Type 10054-S" (36-position) single-deck, single-pole rotary switches, designed for complicated range or circuit switching of experimental apparatus or heavy-duty test equipment, have a unique detent mechanism which also provides non-shorting action: ro-

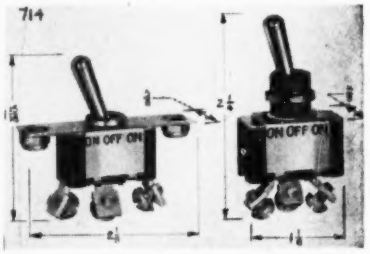


tor arm is lifted as it moves from one contact to next, thus allowing maximum number of usable contacts in smallest space.—*Shallcross Mfg. Co., Collingdale, Penna.*

For further information circle **336** on inquiry card.

Toggle Switches

New "Series IITS and 31TS" toggle switches not only conform to AN and JAN specs but have riveted solid-



silver contacts to prevent loosening and provide maximal conductivity and heat dissipation, and a copper moving-contact carrier for maximal conductivity and minimal temperature rise.—*Micro Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.*

For further information circle **337** on inquiry card.

Miniature Servomotors

New "Precision Motors" are approx. 1 in. in diameter and slightly over 1 in. long; are available for frequencies from 60 to 400 cps. and in 2-,

4-, or 8-pole construction. Stall torque ranges from 0.25 to 0.35 oz.-in. Output shaft can be supplied with or without integral pinion. Units can be supplied to meet rigid military specifications with regard to humidity, temperature, vibration and altitude.—*Dep't R, G-M Laboratories Inc., 4300 North Knox Ave., Chicago 41, Ill.*

For further information circle **338** on inquiry card.

Instrument Motor

New reversible two-phase balancing motor having a rated speed of 333 rpm. at no-load, was designed for use in maker's line of recording instruments but can be applied to other instrumentation devices. When applied to recorders, it provides requisite torque to drive pen carriage full

Why take a chance on

PARTS FAILURE?

Like the proverbial chain that's only as strong as its weakest link, so a delicate instrument can be only as accurate as each of its component parts. So why risk your original investment in a highly sensitive Bristol instrument by buying a doubtful replacement part?

All Bristol parts are designed, engineered, and inspected to fit a specific instrument, to perform with complete accuracy even under rugged service conditions.

You wanted the best—and you got it, when you bought Bristol. So don't take chances when it comes to replacement parts. Only genuine Bristol parts are made to original Bristol blueprints—naturally they'll fit better and perform better—longer. Write to The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

3.15

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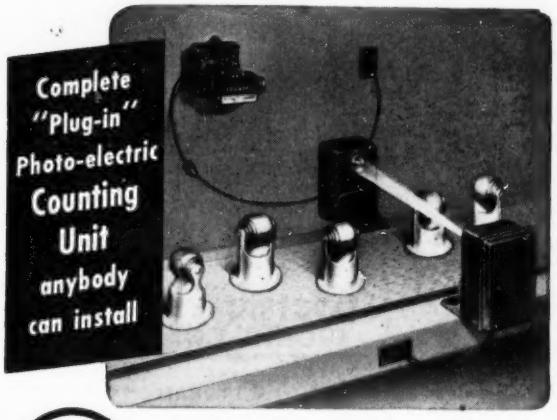
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For further information circle 107 on inquiry card.



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MODERN COUNTING DEVICES

- Stroke and Revolution Counters
- Coil Winding Counters
- Electric Counters
- Automatic Batch Counters
- Actuating Switches

Ideal for counting objects of irregular size or shape, objects too small or too light to operate a switch, freshly painted or hot objects, fresh food, etc.

Factory-adjusted and wired for plug-in connection to lighting outlet. (Also furnished for permanent connection.) Requires no technical skill.

Includes rugged, heavy duty Wizard Electric Counter, also rugged, industrial quality Actuator and Light Source housed in cast aluminum cases with adjustable mounting brackets.

Ask your PIC representative or send for literature.

PRODUCTION INSTRUMENT COMPANY
702 W. Jackson Blvd., Chicago 6, Ill.

For further information circle 108 on inquiry card.

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PYRHELIOMETER
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Eppley Pyrheliometers are used for solar radiation measurements at ninety-eight weather stations in the continental United States, Canada, Alaska, Greenland, Iceland, Caribbean Sea, and the Pacific Ocean. Sixty-two of these stations are under the direction of the United States Weather Bureau.

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For further information circle 109 on inquiry card.

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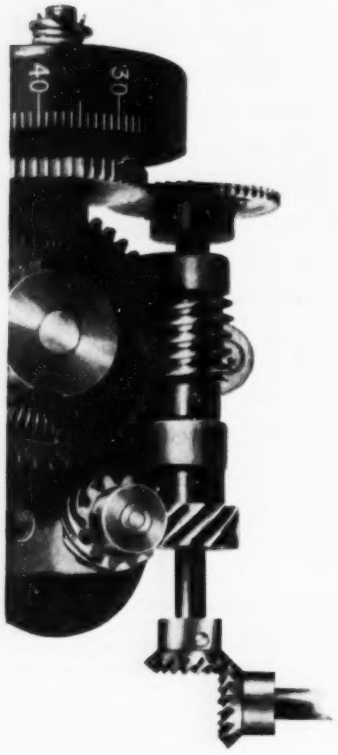
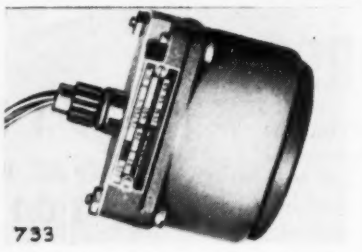


We Invite Your Inquiry

For further information circle **110** on inquiry card.

NEW INSTRUMENTS



scale in about 1.8 seconds.—*Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

For further information circle **339** on inquiry card.

Rotary Converters

New "Custom" d-c.-to-a-c. converters supplement maker's "Super" Converters; are of 300-, 400- and 500-watt

capacities; operate from battery or line of 12, 24, 28, 32, 64, 115 or 230 v.dc.; are available with manual frequency control for heavy-duty measuring devices, etc.—*Carter Motor Co., 2640 N. Maplewood Avenue, Chicago 47, Ill., Dept. 21.*

For further information circle **340** on inquiry card.

Sealed Connectors

New "M-7500 Series" hermetically-sealed connectors withstand 100-*G* mechanical shock; thermal shock from 500-F. oil to liquid air; voltage breakdown of over 1,000 v.; moisture, corro-

sion, high pressure, and fungus. One end mates with standard AN (MIL) types; other end has a tapered and serrated surface for mechanical anchor, whose strength plus high melting temperature of connector's hard-glass insulation permit soldering or welding connector to housing without danger of breaking or melting seal. —*Monowatt Dep't, General Electric Co., 95 Hathaway St., Providence 7, R. I.*

For further information circle **341** on inquiry card.

Stabilized Quartz Crystals

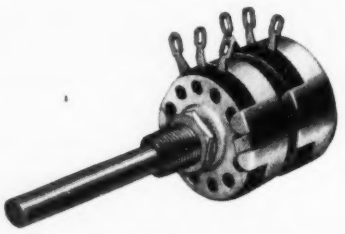
New "Models G-9J and G-9" crystals represent an adaptation of tube manufacturing techniques, are

wire-mounted in 6V6GT envelope with octal base, are available with gold- or silver-plated crystals, in a varied range of frequencies and characteristics.—*James Knights Co., Sandwich, Ill.*

For further information circle **342** on inquiry card.

Tandem VDRs

New "Type AB" 2-watt molded composition voltage-dividing resistors ("potentiometers") consist of two



units mounted in tandem and controlled by rotation of one shaft; have a 2-in. long shaft and independent electrical connections; are available in linear curve type, in seven resistance values from 10,000 ohms to 1 megohm.—*Ohmite Mfg. Co., 4897 Flournoy St., Chicago, Ill.*

For further information circle **343** on inquiry card.

ELECTRICAL AND ELECTRONIC COMPONENTS

Plasmatron

New "Development Type RXB-103005 Plasmatron" is a gas-filled electron tube in which a relatively large current may be controlled by a small current: by directing a stream of electrons into inter-electrode space of a hot-cathode type diode. Available plate current is substantially greater than with a similar vacuum diode. Plasmatron is essentially a linear current amplifier and possesses high current handling ability of a gas tube without sacrificing continuous control of that current by the equivalent of a grid. Plate characteristic is similar to that of a conventional pentode but with minimal tube voltage drop as low as about one volt. Maximum anode voltage is limited by ionization potential of the gas (about 25 volts for

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For further information circle 111 on inquiry card.

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For further information circle 112 on inquiry card.

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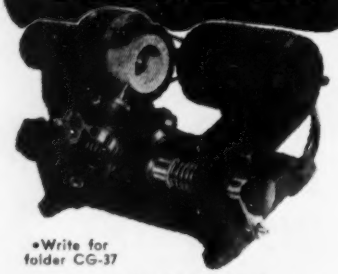

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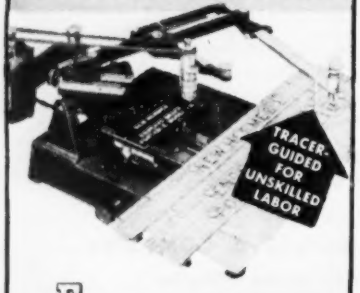

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For further information circle 115 on inquiry card.

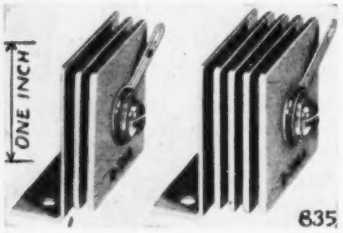
NEW INSTRUMENTS

helium used in present development type). If anode potential rises above this limit, diode current is then limited and controlled only by load resistance and supply voltage. "RXB-103005" is available in small orders; 4-week delivery.—*Red Bank Div., Bendix Aviation Corp., Eatontown, N. J.*

For further information circle 344 on inquiry card.

Selenium Low-voltage Regulators

New selenium regulators are for regulation of relatively low d-c. voltages: "Type D-568" for d-c voltages in order of 1.5 volts; "D-923" 2.0

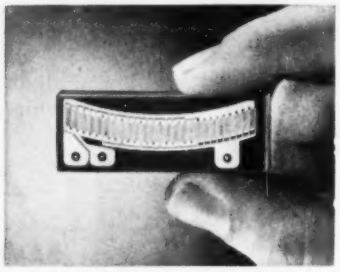


volts; "D-1046" 3.0 volts. For operation, new regulator is connected in shunt with load, and a voltage-dropping resistor in series with source voltage and load. Regulation is accomplished by utilizing forward characteristic: voltage across VDR varies inversely with changing load current and desired voltage is maintained.—*International Rectifier Corp.*, 1521 *E. Grand Ave., El Segundo, Calif.*

For further information circle 345 on inquiry card.

Miniaturized Circuits

New "In-bedded" circuits, for miniaturization of circuits and components, have solid metal conductors (formed into any desired circuit pat-



tern) embedded into face of a suitable insulating base (plastic, glass or ceramic). Exposed faces of conductors can be molded to lie in same geometric plane as face of insulating base for smooth-riding low-friction commutator applications. Conductor line widths as narrow as 0.001 in. can be produced, also intricate designs.—*Vacumet Inc.*, 1267 *N. Clybourn Ave., Chicago* 10, *Ill.*

For further information circle 346 on inquiry card.

Variable-resistor Kit

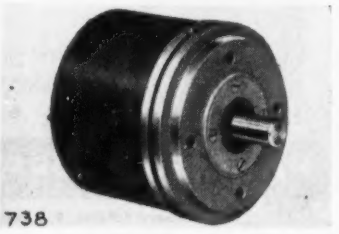
New "Pot Kit B," for experimental laboratories requiring maximum flexibility in "bread-boarding," comprises

"Unitized Type RVC2" voltage-dividing resistors, mounting plates, clamp right, "Servocalculator" and brochure; permits user to prepare single or ganged VDRs, linear and non-linear.—*Servotrol Co., Framingham Centre, Mass.*

For further information circle 347 on inquiry card.

Precision-grade VDR

New "Model 85171A Spiralpot" slide-wire multi-turn variable resistor ("potentiometer") is now available in precision grades of 0.05 and 0.025

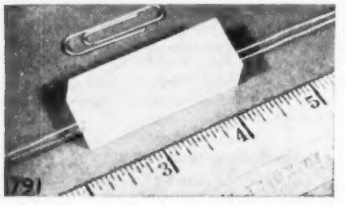


percent linearity, with both independent and zero-based linearity ratings; rotational tolerances of plus 1 degree minus 0; infinite resolution; starting torque of 0.6 oz.-in.; service life of one million cycles equivalent to 20 million revolutions in a 10-turn unit.—*G. M. Giannini & Co., Inc.*, 117 *E. Colorado St., P. O. Box N, Pasadena* 1, *Calif.*

For further information circle 348 on inquiry card.

Subminiature Delay Line

New "Part No. A1557" potted delay line weighs 0.68 oz; can be firmly mounted on a panel of any type; is



of lumped-constant design. Time delay is 2.5 microseconds (5 usec. if a reflection is used); attenuation is 2 db. A number of units in series give multiples of basic 2.5 usec. delay. Characteristic impedance is 2800 ohms.—*Jacobs Instrument Co., Bethesda* 14, *Md.*

For further information circle 349 on inquiry card.

High-impedance Delay Cable

New "Type HH-2000" delay cable (a further development of "Type HH-1500") is designed to delay signals (both sine waves and pulses) for periods from a fraction of one microsecond to several usec. Time delay

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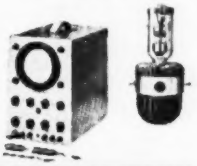

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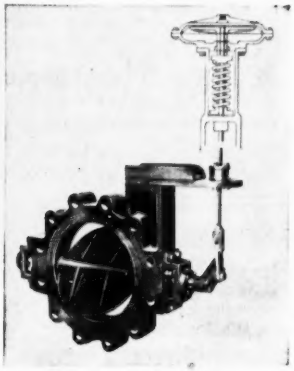

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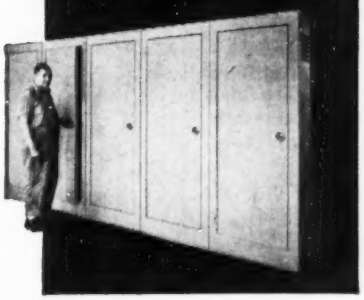

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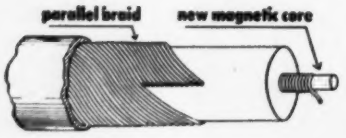
For further information circle 120 on inquiry card.

NEW INSTRUMENTS



of 0.11 usec. per foot; nominal characteristic impedance 2200 ohms. Bandwidth (3 db down) for a one microsecond delay is more than 0-10 Mc. and correspondingly larger for smaller time delays.—*Columbia Technical Corp., 5 East 57th St., New York 22, N. Y.*

For further information circle 350 on inquiry card.

HV Mica Capacitors

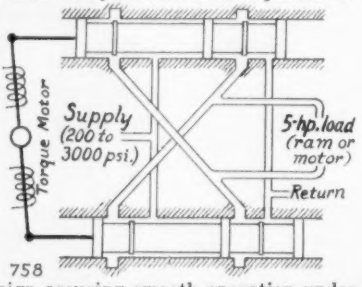
New "Hivomikes," high-voltage midget mica capacitors, are now available in ratings of 1000, 1500, 2000 and 2500 vdc working; complete range of capacitance values in each voltage rating. Values are further selected to cover both conventional and Preferred Number system.—*Industrial Div., Cornell-Dubilier Electric Corp., South Plainfield, N. J.*

For further information circle 351 on inquiry card.

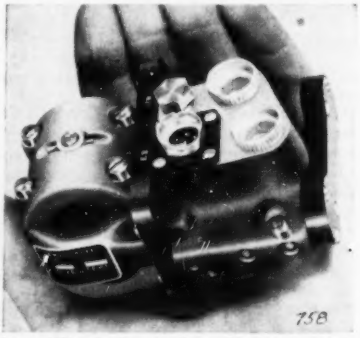
VALVES

Hydraulic Servovalve

New "Model 4" miniature single-stage uncompensated servovalve has balanced symmetrical twin-piston de-



sign assuring smooth operation under adverse vibration and lateral acceleration conditions. Both pistons are accessible for mechanical actuation; may

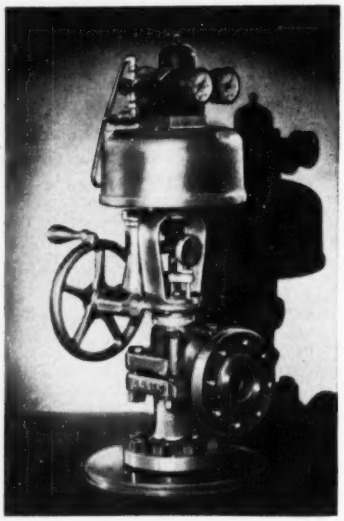


be utilized for safety limit stops in servosystems. Torque motor balance current: 20 ma.; continuous current (max.): 40 ma.—*Midwestern Geophysical Laboratory, 3401 S. Harvard, Tulsa, Okla.*

For further information circle 352 on inquiry card.

Combination Automatic and Manual Control Valve

New "Models 1520 SMW and 1560 SMW" control valves have, in addition to maker's "Domotor" null-type

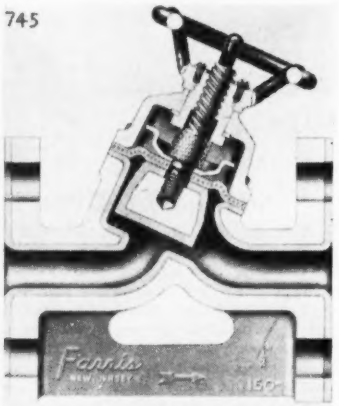


power positioner, a side-mounted handwheel mechanism providing supplementary control during start-up periods or when system is shut down temporarily for instrument repair. Handwheel may also be used as an adjustable limit stop for automatic-control valve plug. Standard valves control pressures to 5000 psi.; specials to 50,000 psi.—*The Annin Company, 3500 Union Pacific Ave., Los Angeles 23, Calif.*

For further information circle 353 on inquiry card.

Diaphragm-principle Valve

New "X-V Series" diaphragm-principle valves are primarily designed for shut-off, throttling and control of acids, chemicals and other



corrosive and abrasive fluids. Principal feature is individual functioning of diaphragm and disk: sealing mechanism and seating disk are accomplished separately; diaphragm is not subjected to seat wear and abrasion; design makes it possible to close valve in event of a diaphragm failure.—*Farris Flexible Valve Corp., 610 Commercial Ave., Palisades Park, N. J.*

For further information circle 354 on inquiry card.

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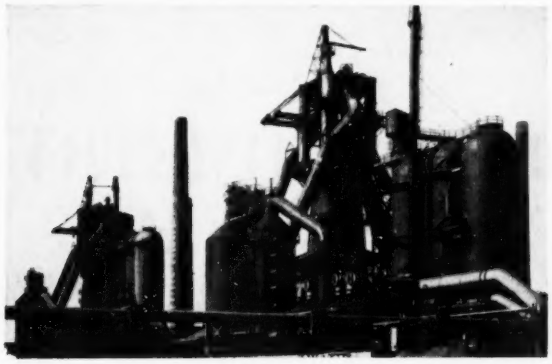

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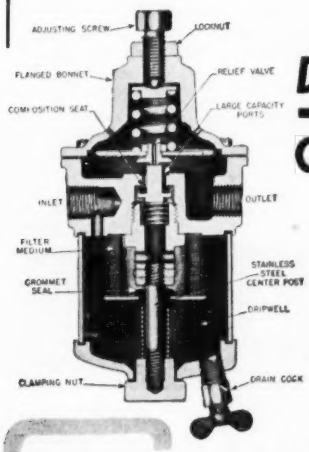

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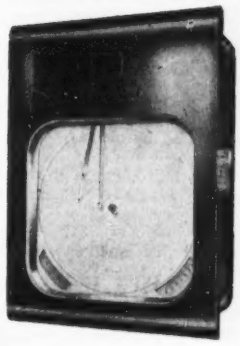

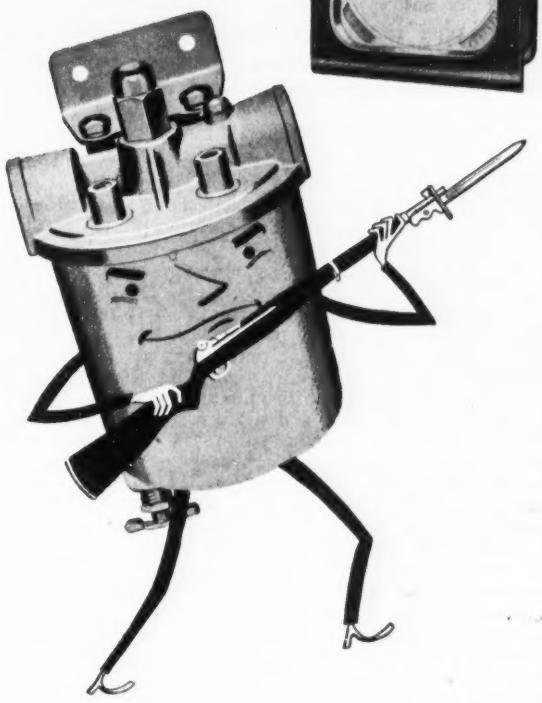

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Open-hearth-furnace

BATH TEMPERATURE PYROMETRY

A survey of users of thermocouple-type and radiation-type immersion pyrometers reveals the favorable and unfavorable factors associated with both types. Sensitive elements, recorders, and users' opinions are presented.

by L. H. VEIOCK
Heppenstall Co.

STEELMAKING techniques of today are placing heavier demands on more accurate methods of steel-bath-temperature measurement. The evolution of the methods in use today has developed to the point where laboratory results of a few years ago are now possible in everyday practice in the openhearth shop.

The human eye has been called the first molten-metal pyrometer. The experienced melter, with the aid of shaded glasses which act as a color pyrometer, can estimate the temperature of molten metal by observing the reaction between slag and metal, the brightness of the slag surface, the fluidity of the slag, and the brightness of the metal when poured from a sampling spoon. The optical pyrometer proved to be a valuable tool as early as 1917 when Dr. Burgess suggested that a value of 0.4 be used for the emissivity of liquid iron and steel. The immersion thermocouple became a reality in this country in 1933 when Dr. G. R. Fitterer reported satisfactory results with his design using carbon versus silicon-carbide as the sensitive element. In November, 1935, Collins and Oseland were granted a United States patent covering an open-end air-purged sighting tube, through which an optical pyrometer sighted on the molten metal. This type is now sold commercially, using a small radiation unit to detect the temperature.

The primary measuring instruments which are currently popular are the immersion thermocouple (using a platinum versus platinum-rhodium element) and the immersion "Rayotube," sometimes called the blow-tube pyrometer.

Immersion Thermocouple System

Fig. 1 shows a schematic diagram of a thermocouple and its position in the open hearth when taking a temperature reading. Although Fig. 1 shows a thermocouple with a curved-head assembly, the straight-head type is becoming increasingly popular. In furnaces which are small (such as forty or fifty tons capacity) the depth of immersion can be controlled fairly well. However, in larger furnaces where the couple is forced into the bath by raising the end of the unit against the wicket hole, some questionable readings have been reported.

Several immersion thermocouple designs have been made available commercially, although most of the units in service today are of the "home-made" type. Some interesting features have been developed as the result of each interested man attempting to make a better unit as well as one adapted to his own plant's needs. The over-all weight of the immersion unit has been reduced until now the average weight is about thirty-five pounds. Better means of protection for the thermocouples result from use of alumina and high-temperature porcelain twin-bore insulators. One plant reports discouraging results through use of a less expensive grade of fused-silica tip. The outer protection for the immersion units varies from ceramic materials coated with fire clay, to wire wrapping over thin-walled tubing, to hollow sections of graphite. The head assemblies also have been going through a stage of improvement. Whereas heads with a 90-degree angle were common a few years ago, the angle has been reduced to 35 degrees in some applications, and the trend seems to be toward using a straight head assembly.

Fig. 2 shows a cut-away view of a thermocouple head assembly which is available commercially. The interesting features include stainless-steel nose piece, metal plug with stainless-steel bushing and quartz tip, and the method by which the excess thermocouple wire is stored in the body of the immersion units.

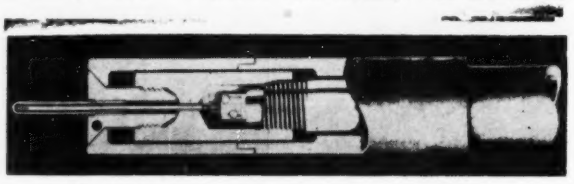


Fig. 2. Cut-away view of a thermocouple head assembly.

Most shops are careful of possible contamination of the thermocouple by either cutting off a portion of the wire from the hot junction after fifteen or twenty immersions or by strict checking of the unit either by the comparison method or check-furnace method. The original length of the platinum versus platinum-rhodium wire used for the thermocouple varies in different plants from six inches to eight feet. The plants using short lengths of wire must be careful of cold-junction errors when using the same unit for successive immersions. Some plants report that units are giving successive readings after a delay of only eight or ten minutes. Silver soldering of the thermocouple wire to

Presented at the Conference "Instrumentation for the Iron & Steel Industry," April, 1952, Pittsburgh, Pa.

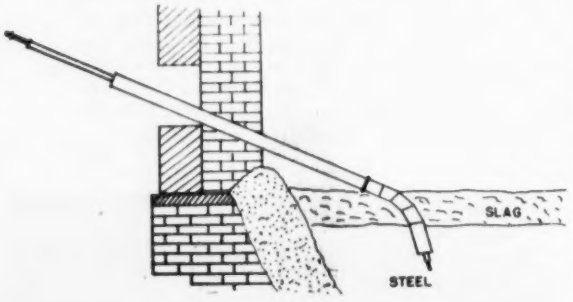


Fig. 1. Immersion thermocouple.

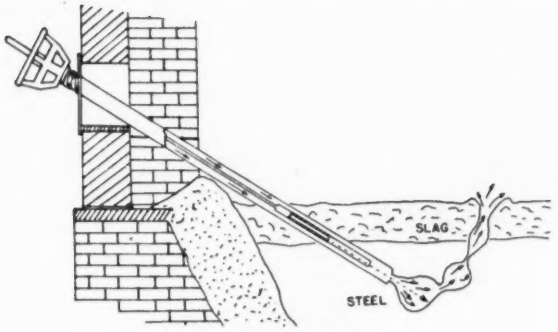


Fig. 3. Radiation pyrometer.

the extension lead-wire is preferred to a mechanical connection in applications where the thermocouple is short.

Radiation Immersion Units

Fig. 3 shows a radiation pyrometer and its position in the bath when taking a temperature reading. This unit also is inserted through the wicket hole in the furnace door, with the splash shield held tightly against the door to prevent sparks from harming the operator. Air is blown down the tube to keep it clear of molten metal and slag, forming a bubble or pocket in the molten metal. The radiation unit sights on this bubble to measure the temperature.

The immersion "Rayotube" equipment is available commercially in only one design. Because of the short time required for taking a reading, together with the air being blown down the tube, the "Rayotube" unit does not reach a dangerously high temperature. A protecting sleeve is used in some cases to keep slag and metal from adhering to the metal tube. Replaceable tips give additional protection to the nose assembly and aperture.

Fig. 4 is a cut-away view of the "Rayotube." The brass nose unit is removable to gain access to the glass window and lens for cleaning any accumulation of dirt. The "Rayotube" is hermetically sealed to minimize cleaning and to afford the best operation.

Recorders

Both thermocouple and radiation types of sensitive elements utilize modern potentiometer-type high-speed recorders, such as the Brown "Electronik" or Leeds & Northrup "Speedomax." A split door-glass on the recorder affords easy access to the chart for notations. Recorders for use with the immersion thermocouple are available from at least two instrument manufacturers with features such as (1) double-range scales with low ranges of approximate-

Fig. 4. Cut-away view of "Rayotube."

ly 200 deg. F. for checking polarity of thermocouple, (2) automatic standardization which is actuated when the pen moves upscale, (3) high-speed chart drives which operate only when the pen is recording in the high-temperature section of the scale, (4) external signal lamps to indicate the progress of the reading, with a red lamp glowing when the pen has recorded maximum temperature; signal gongs or "howlers" may be connected to this circuit to give an audible signal when maximum temperature has been reached, and (5) down-scale fail-safe feature to drive the pen to the bottom scale in event of thermocouple burn-out.

Fig. 5 is a typical chart record of an immersion thermocouple reading which indicates the automatic standardization feature. This new feature deserves considerable merit inasmuch as the recorder is standardized during the course of every reading without having any time added to the immersion period.

The recording equipment for use with the immersion "Rayotube" is available only from Leeds & Northrup Company, and is designed specifically for this application. The immersion unit, the checking unit, air-control unit, and "Speedomax" recorder are sold as a complete, coordinated system.

Users' Opinions on Thermocouple Units

A number of metallurgists, research department heads, open-hearth superintendents, melters, and men in instrument and maintenance supervisory positions were interviewed recently in an effort to determine just what type of molten-metal temperature-measuring equipment is now in use in the various open-hearth shops. Although it was impossible to contact all plants using open-hearth melting facilities, the following information is representative of the plants in this area.

Favorable

The following favorable comments have been expressed by the users of thermocouple-type equipment:

Independent of Steel Emissivity. Corrections are not necessary regardless of bath composition. The immersion thermocouple reads TRUE temperature.

Portability. Light weight and easy to handle with only one thin, duplex lead-wire from the unit. One man usually can handle the equipment without strain.

Reliable readings. The operator can check himself at any time by taking a duplicate reading with a spare unit. The thermocouple system does not require separate calibration for each recorder.

Lower initial costs are favorable to the small companies. This gives the smaller shop a lower cost-per-ton figure than is possible with other types of equipment.

Operating costs are reasonable. Although there is considerable difference in the figures quoted as operating costs and cost per reading from company to company, the average figure seems to be less than eighty cents per reading. Some companies report costs as low as forty-nine cents, but these were in the minority.

Operating personnel express greater confidence in the thermocouple system. The majority of the plants interviewed expressed a feeling of quicker acceptance by operating personnel for the thermocouple system.

Unfavorable

The following unfavorable comments have been expressed by users of the thermocouple system:

Fragility of the thermocouple is the greatest objection. The fused-silica tips are brittle and one shop reports considerable breakage from rough handling of the equipment.

Personnel training in the proper use of the immersion unit is time consuming.

Storage problem in some shops is serious, especially when space near the furnace is at a premium. Where two or three units are used simultaneously and must be stored near the furnace, the problem of mechanical damage from other equipment is present.

Repair of heads presents a problem only in those shops which use refractory cement as protection. The heads must be allowed to dry thoroughly before using again.

Users' Opinions on Radiation Units

Favorable

The following favorable comments have been expressed by users of radiation immersion equipment:

Will stand mill abuse much better than the corresponding thermocouple unit. It is a rugged mill tool.

Continued on page 752

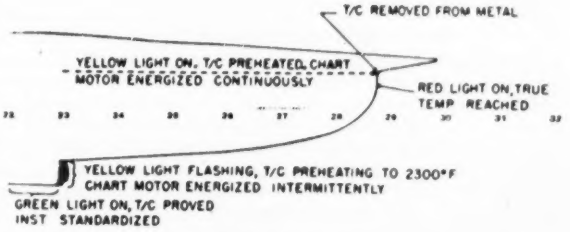
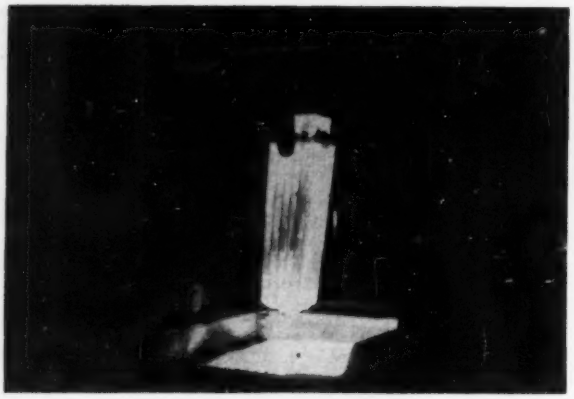
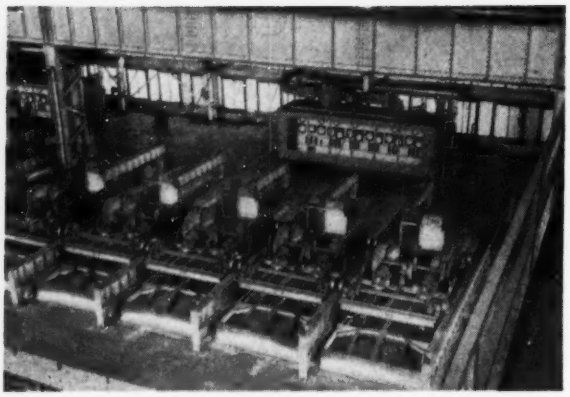

T/C REMOVED FROM METAL
YELLOW LIGHT ON, T/C PREHEATED, CHART MOTOR ENERGIZED CONTINUOUSLY
RED LIGHT ON, TRUE TEMP REACHED
YELLOW LIGHT FLASHING, T/C PREHEATING TO 2300°F CHART MOTOR ENERGIZED INTERMITTENTLY
GREEN LIGHT ON, T/C PROVED INST STANDARDIZED

Fig. 5. Typical chart record.



Modernized early fuel-fired soaking pit.



View of completed pits at Bethlehem Steel.

Soaking-pit Instrumentation

The new soaking-pit installation at the Johnstown Plant of Bethlehem Steel Co. illustrates modern concepts of pit-furnace instrumentation. Important considerations are fuel control, pit-temperature control, combustion control, and pit-pressure control.

by F. R. PULLEN
Bethlehem Steel Co.

UNTIL late in the 19th Century, it was common practice to charge cold steel from the stockyard into the rolling-mill furnaces. Near the end of the 19th Century, however, the practice of rolling hot steel directly on the mills began. This produced a complication because the coordination of the intermittent operation of the melting shop and the continuous rolling operation of the mill required an "accumulator." These were true "soaking" pits in that the hot ingot was charged into individual holes which were well insulated and unheated. Thus, the cooling of the ingot was not only retarded, but a degree of temperature equalization hitherto unheard of was attained. In fact, further reheating often was unnecessary and the steel was rolled directly from the pit.

It was soon realized that heated pits would be even more beneficial. Thus the simple, but misnamed, fuel-fired soaking pit came into being. These were fired with coal or producer gas, and they soon replaced the ingot-heating furnaces at the roughing or blooming mills.

These pits were of the reversing regenerative type and, in light of modern construction, quite crude. Gradual improvements have brought us to the present conception of the modern soaking pit or, as it should be termed more properly, the modern ingot reheating furnace which is characterized by (1) low fuel-consumption, (2) uniformly heated ingots, (3) minimum scale formation, (4) high production, and (5) low maintenance cost.

Modern Construction

Low fuel-consumption, with any given set of charging conditions, can be obtained only through use of recuperation, or regeneration. The ratio of heat absorbed in the steel to heat losses from the furnace must be high. This requires effective cover sealing, good refractory insulation, and efficient waste-heat-recovery systems. The mixing of air and fuel in the proper proportions to insure effective heat liberation in the pit furnace is also essential.

To insure *uniformly heated ingots*, the location of the burner and the provision of sufficient combustion space are all-important. In addition, proper ingot-charging patterns are important because short-circuiting of products of combustion must be prevented. The pit must be operated under the proper conditions of furnace draft, or pressure, to prevent stratification of flue gases and infiltration of cold air.

Minimum scale formation is dependent on control of fuel-air ratio, burning rates, and air infiltration. The beneficial effect of good combustion control can be completely overcome by improper mixing of the fuel and air, permitting stratification or admission of excessive quantities of infiltrated air.

High production rates are obtained by maintenance of a high load factor. In other words, the pits are charged and drawn rapidly, loaded properly, and have little down-time. The use of adequate skilled supervision is essential. Use of

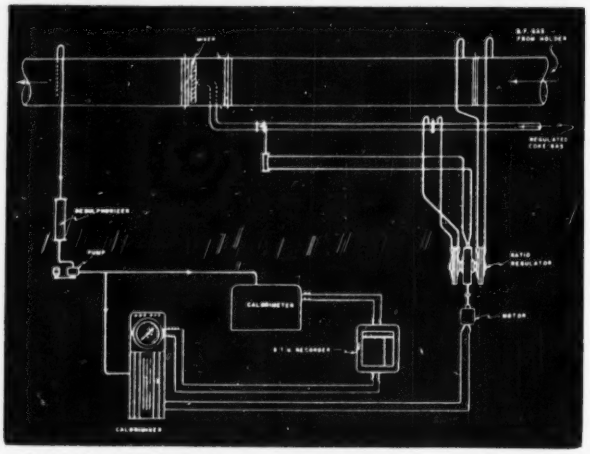
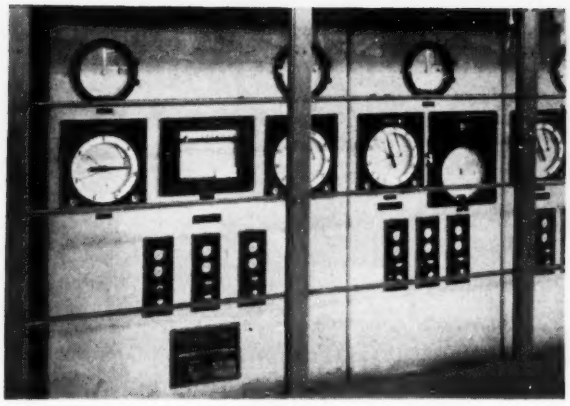
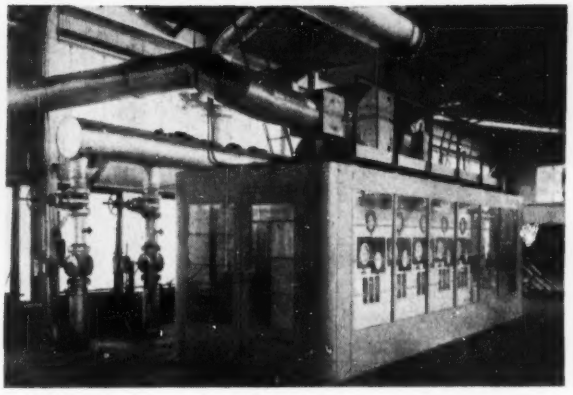


Fig. 1. Fuel mixing station for mixing blast-furnace gas with regulated coke gas in a ratio controlled by BTU content.

Presented at the Conference "Instrumentation for the Iron & Steel Industry," April, 1952, Pittsburgh, Pa.



Pit panel.



Battery panel.

properly engineered and installed instrumentation is also essential to the continued maintenance of high production.

All of the above factors will produce the flexibility and low maintenance costs which are also requirements of good soaking-pit operations.

The new soaking-pit installation at the Johnstown Plant of the Bethlehem Steel Company consists of 30 holes of one-way top-fired recuperative pits. They are 7½ feet wide by 20½ feet long by 13¼ feet deep, and are fired with a mixture of coke-oven and blast-furnace gas regulated and controlled to approximately 130 BTU per cubic foot.

Fuel Control

The use of low-BTU mixed fuel creates a need for close control of the gas-mixing station because a slight variation in BTU content of the fuel represents a considerable fluctuation percentagewise, which in turn operates against good fuel-air ratio control. For example, a fluctuation of 10 BTU in mixed 130-BTU gas represents a fuel input fluctuation of 7.7 percent. On a pit furnace designed for a 15-million-BTU input, this represents a fluctuation of 1,170,000 BTU. Although it is possible that this particular error would average out so that the hourly heat input is correct, the production loss due to lower flame and furnace efficiency cannot be recovered. A fluctuation of 1 percent oxygen in the flue gas in this case represents a change of approximately 10 percent in excess air; while in the case of coke-oven gas for example, it would only be about one half of this variation.

In this particular application, the need for close control of the mixed fuel gas was further complicated by the physical arrangement of the blast furnaces, which includes one ferro-manganese furnace. Fluctuation in blast-furnace operations would cause fluctuation in quality of the blast-furnace gas over a range of approximately 95 to 125 BTU per cubic foot. These, of course, would be rapid in event of furnace stops, etc. For this reason it was decided to install a BTU-controlled mixing station rather than one operating strictly on a straight volumetric ratio control. Fig. 1 shows the BTU-controlled fuel-mixing station. Fig. 2 compares BTU control with volumetric control of fuel ratio.

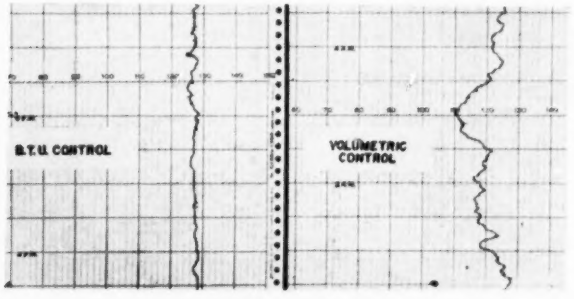


Fig. 2. BTU recorder chart.

The rapidity with which the changes in fuel quality occur made it necessary to install a calorimixer control, which is continuously supervised by a controlling calorimeter. The calorimixer controller senses changes in fuel gas and acts to correct the deviation prior to the time at which the calorimeter measures the total amount of deviation. The controller operates a drive motor which changes the ratio of blast-furnace and coke-oven gas so as to maintain the proper fuel quality. On low-BTU fuel-fired pits, the maintenance of fuel quality is absolutely essential.

The equipment available to measure and control BTU content could be improved. Its sampling lag is high, and the present control system is complicated. A faster measuring and analyzing system incorporated with improved control characteristics which are available, would be desirable.

Pit Furnace Instrumentation

Assuming that the mixing station is functioning properly and furnishing a fuel of constant BTU content, we next pass on to the pit furnace instrumentation and control system. It would be impossible to operate the modern soaking-pit furnaces and obtain any degree of production without use of instruments. The production rates and quality requirements are such that manual control of the operation is out of the question.

Fig. 3 is a plan view of the pits. Fig 4 is a section thru the pits and recuperators. The 30 holes are grouped in 6 batteries of 5 pits each. The flue gases from each of the pits in a battery are collected in a single flue leading to the tile recuperator. After passing through the tile recuperator, the flue gases enter a metallic recuperator in which the gases are cooled to approximately 1200 degrees F., at which temperature they pass under the stack damper into the stack. The air for combustion is supplied by a 40-ounce turbo compressor, which discharges into the metallic recuperator, and is preheated to approximately 850 degrees F. This air then is fed into the needle of the jet pump to aspirate air through the 2-pass ceramic recuperator. The final air mixture is approximately 1300 to 1400 degrees F. and is supplied to the burners at this temperature. The fuel and air are mixed at the burner port.

Pit temperature is measured at a point on the far wall from the burner, approximately one half of the distance from the bottom to the top. The temperature-sensing element is a radiation-type unit sighting on the closed end of a ceramic tube. An air purge from the combustion-air fan is used to keep the lens clean. Practice has shown it advisable to clean the radiation head and check its calibration about once a week.

Combustion Control System

Fig. 5 shows the combustion control system. The impulse from the temperature-sensing element is measured and recorded on the pit-temperature recorder-controller located on the pit panel board. The controller develops an air-loading impulse proportional to temperature (fuel demand). As the ratio of fuel to air is held constant, either air flow or fuel flow can be controlled by the impulse from the temperature

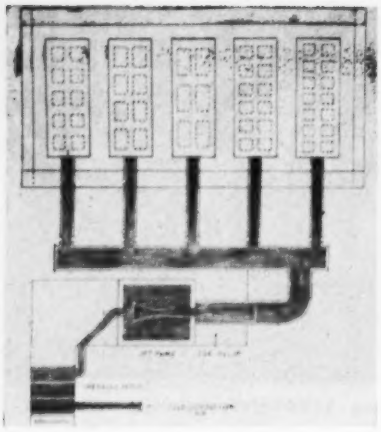


Fig. 3. Plan view of pits.

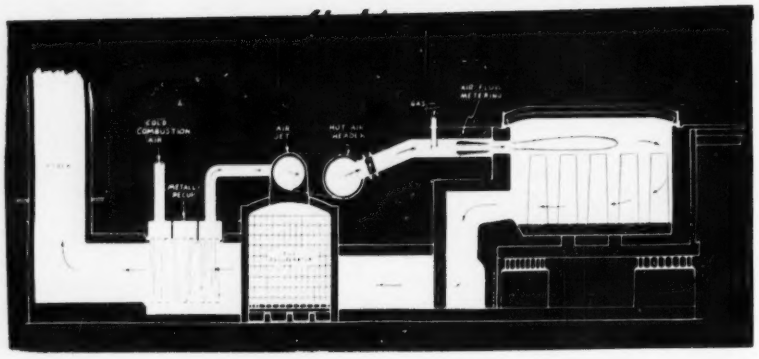


Fig. 4. Section through pits and recuperators.

controller. As air flow is more liable to be limited than fuel, the loading impulse is fed into a valve operator regulating the flow of air to the burners.

The flow of preheated air is measured and the differential pressure thus obtained is used to load one diaphragm system of the fuel-air regulator, which in turn sends out a loading pressure that operates the gas-flow regulating valve. The differential pressure developed across the gas orifice is returned to the gas regulator to oppose the air-flow measurement.

This would be entirely adequate if it were not for the fact that the use of preheated air of varying temperature causes a shift in air-fuel ratio due to the variation in density of the air at the point of measurement. Therefore, it is necessary to compensate the flow of air or gas to correct for the error in air-flow measurement whenever the temperature is different from that of the calibrating temperature. This is accomplished by the addition of a *ratio-compensating relay* between the gas-flow relay and the air-gas ratio regulator. The compensating relay receives an impulse from the air-temperature recorder and increases or decreases the balancing loading to the air-gas flow regulator proportionally to the deviation from the calibrated temperature. Although this may seem complicated, it eliminates the need for regulating air-preheat temperature by bleeding cold air into the hot air, and of course permits use of maximum air preheat at all times. Solenoid valves (not shown) have been installed on the loading lines to cause them to close instantly upon opening the pit cover.

Pit-pressure Control

In addition to pit temperature and air-gas ratio control, an essential part of the system is pit-pressure control. In this installation the pit pressures are controlled as a unit by maintaining a fixed flue draft on the collecting flue between the pits and the recuperator. The flue draft is measured and applied to a draft regulator which operates the main damper between the metallic recuperator and the stack (Fig. 6). The flue draft is maintained at a pressure or draft so as to maintain a desired pressure on the pit furnace at minimum fuel flow. The pressure will be slightly higher at high gas flows. It is necessary that the damper operator be fast-acting and yet stable at all times. This was accomplished by use of oversize pilot valves and feed-back relays. Fig. 7 shows recorded pit pressure on one of the pits, and also flue draft and gas pressure.

The fluctuations in pit pressure and flue draft are brought about when it becomes necessary to open the pit cover. A solenoid valve has been installed in the master loading circuit of the flue-damper regulator. This solenoid is energized by opening any one of the pit covers and automatically adjusts the flue-draft regulator setting so as to maintain, as nearly as possible, the proper draft to prevent a loss of flue products through the open pit. It also opens the stack damper sufficiently to permit fast recovery of fuel and air-gas flow as soon as the cover is closed. Without this readjustment of flue draft, the normal position for the stack damper during charging or drawing would be closed. This would not only add to heat losses through the open pit, but would make it necessary to reduce the speed at which the fuel and air are returned to the pit when the cover is again closed.

All instruments for the operation of each pit are located on the control panel, grouped by individual pits. Only instruments and manual-control stations which the operators have cause to adjust are located on the pit or battery panel. All others which require calibrating and adjusting

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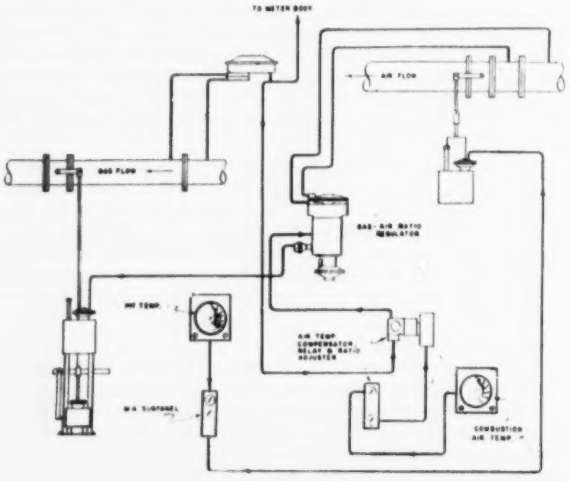

Fig. 5. Combustion control system.

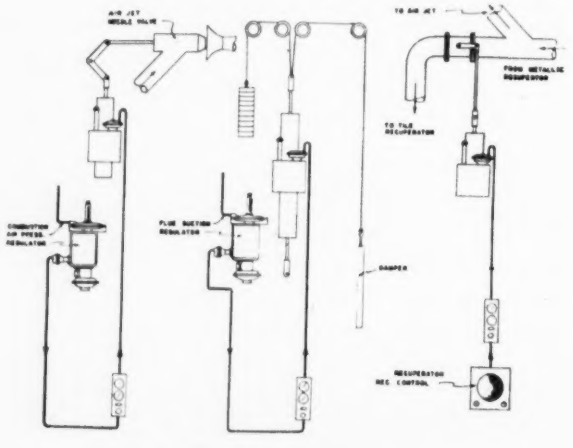

Fig. 6. Battery combustion control system.

Control of Chemical Processes

Part V of this series presents the principles of proportional control, the basic continuous-control action. Important factors associated with proportional control are offset, proportional band, stability, and criteria of good control. The deviation reduction factor and subsidence ratio are useful in treating plant response to controller action.

by
A. J. YOUNG†

V. PROPORTIONAL CONTROL

Discontinuous methods of control are in general cheaper to apply than continuous methods. The latter are, however, widely used where the former are not capable of giving sufficiently close control.

Practically all continuous controllers are based on proportional action. Wherever possible, proportional action is used alone, but process characteristics often demand the addition of either integral or derivative action, or both. As its name implies, proportional action is (BSI definition 2404): A control action varying directly with deviation—that is,

$$V = -K_1\theta$$

where V is control action on regulating unit, θ is deviation of controlled condition from the desired value, and K_1 is a coefficient.

The negative sign in the equation shows that the action is directed to counteract the deviation.

If the control action V on the regulating unit causes the regulator to produce a potential correction* Θ of the controlled condition, such that $\Theta = (K_r)\ (V)$ then we can write:—

$$\Theta = -K_1(K_r)\,(\theta) \qquad (1)$$

where $\mu = K_rK_1$ and is known as *the proportional control factor.*

The definition of proportional control factor is as follows (BSI definition 2505): The ratio of the potential correction to the deviation in proportional control.

Offset and Proportional Band

As the position of the regulating unit is proportional to the deviation (θ), it follows that for each value of θ there is a specific regulating unit position and, therefore, a given input to the system. If the demand increases, the regulating unit can only increase input to satisfy this demand by moving to a new position. But this movement can only be caused by an increase in deviation (θ). Therefore the process temperature (or other controlled condition) must decrease until such a deviation exists as will cause the regulator to open sufficiently to give the increased input to bring the process to equilibrium. If no further process changes occur, this equilibrium will be maintained but at a lower level than the desired value. The new level at which the temperature is controlled is defined as the "control point," and the difference between desired value and control point is called *offset* (Fig. 5-1).

The magnitude of the offset for a given load change is dependent on the value of K_1, which determines the regulating unit movement per unit deviation. If K_1 is large, offset will be small and *vice versa*. The value of K_1 is determined by the "proportional band" of the controller, which is (BSI definition 2502): The range of values of the controlled condition which operates the regulating unit over its full range. This range is expressed as a percentage of the scale range. (Fig. 5-2).

It is evident that to keep offset small, the proportional band must be narrow; also, that the control point must remain within the proportional band because when the deviation reaches the limits of the band, the regulating unit has also reached the limits of its travel. If any further demand is made by the process, the regulating unit will be "over ranged" and the temperature will continue to drift unless it is corrected at a new equilibrium level by the inherent regulation of the process.

Stability

The need for stability sets a limit to the narrowness of the proportional band which can be used. If the band is made too narrow, any disturbance will cause the system to go into oscillation with an amplitude that may increase

Continued on page 756

* "Potential correction" is the change of potential value of the controlled condition due to the movement of the regulating unit.

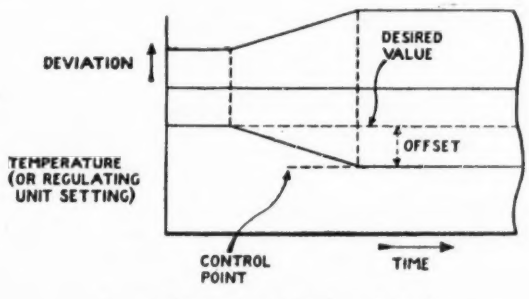

Fig. 5-1. Offset produced by change in load.

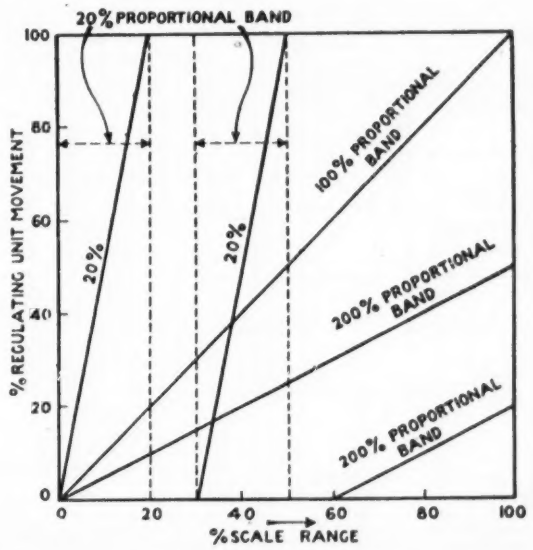

Fig. 5-2. Widths of various proportional bands of a controller.

†Technical Department, Imperial Chemical Industries, Ltd., London. This series of articles originally appeared in the *Industrial Chemist*, England.

An Electronic Approach to

PROCESS CONTROL

By CHARLES J. SWARTWOUT
The Swartwout Company

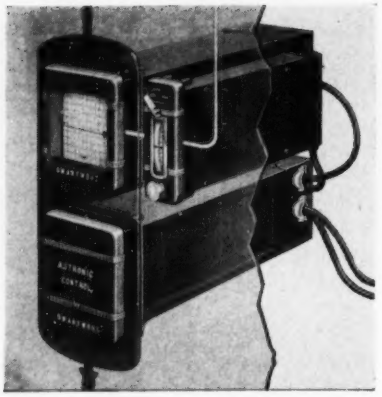

Fig. 1. Phantom view of controller, recorder and manual control mounted on panel.

ELECTRONIC circuits are used in the Swartwout "Autronic" control system to produce the three basic control actions—proportional, reset, and rate.

System Components

Fig. 2 is a block diagram of the "Autronic" system.

The *primary-element transmitter* (Fig. 4) is supplied with 115-volt 60-cycle power, and is connected to the process variable that is to be measured and controlled—pressure, temperature, flow, level, or any measurable variable. The transmitter furnishes a 60-cycle output voltage that is proportional to the variable being measured. This voltage varies from 0.000 to 0.500 volt. All measuring elements are designed to furnish a voltage in this range, and hence are interchangeable.

No vacuum tubes are employed in the transmitters. The transmitters for flow, differential pressure, pressure, and level all utilize a differential transformer for conversion of a small mechanical motion into a proportional a-c. voltage. For temperature measurement a platinum resistance-thermometer element and thermometer adapter unit are used. The adapter unit contains the necessary bridge components to provide the correct a-c. output voltage.

The transmitter output voltage is transmitted to the *controller* and *recorder*, which are independent of each other and may be used either in combination or singly. The output of the controller is a direct current of from 4 to 8 milliamperes. This current is transmitted to the power relay.

The *power relay* (Fig. 5) is an electro-pneumatic force-balance transducer that furnishes an air-pressure output proportional to the current output from the controller. It converts the electrical output of the controller into a proportional air pressure for operating the final control element.

The *manual control* is an optional unit that provides for remote manual operation of the valve, and means for switching from manual to automatic operation without disturbing the process. This unit, like the transmitter and power relay, has no vacuum tubes.

Fig. 1 shows the manner in which the recorder, controller, and manual control are mounted. Although the controller is designed for panel mounting, it may be installed in any convenient location. The 3-inch strip-chart recorder is shown. The "Type A7C" controller with built-in set-point adjustment has screwdriver adjustments for setting reset rate, proportional band, and rate time. Reset and rate action can be turned off if desired.

Fig. 3 is a block diagram of the controller. This unit is made up of four sections in cascade—the proportional amplifier, phase-sensitive rectifier, rate amplifier, and reset amplifier.

Proportional Amplifier

The signal voltage input (from the primary-element transmitter) and the set-point voltage input are both connected to the a-c. amplifier. These two input voltages are compared and their difference is amplified. The proportional-band setting controls the gain of the a-c. amplifier, whose output is proportional to the difference in the two in-

*Presented at the AIEE Conference, Benjamin Franklin Hotel, Phila., Nov. 17-18, 1952.

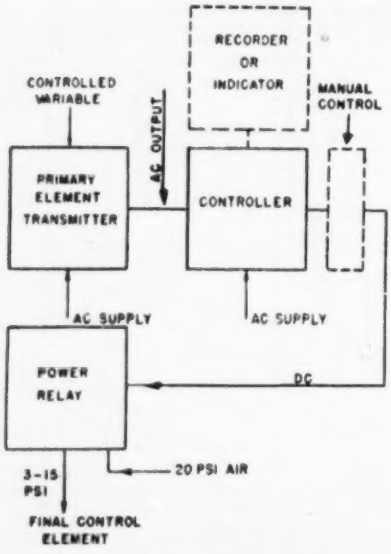

Fig. 2. "Autronic" control system.

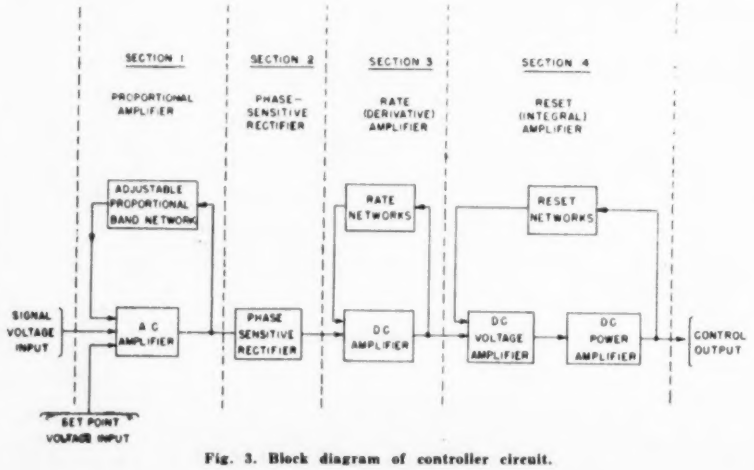

Fig. 3. Block diagram of controller circuit.

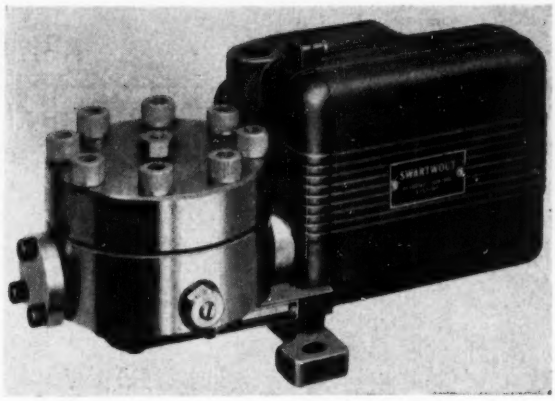

Fig. 4. Differential-pressure primary-element transmitter.

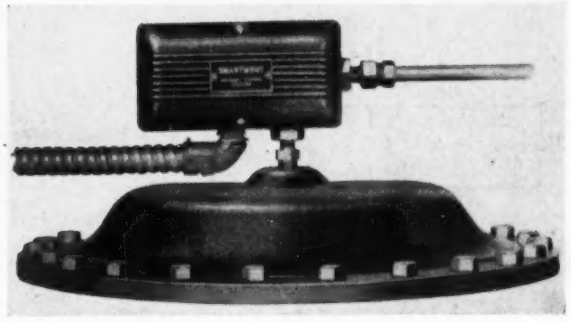

Fig. 5. Power relay mounted on valve diaphragm.

put voltages. The control action operates to reduce the difference between set-point and signal voltages to zero.

The over-all amplification of the proportional amplifier is varied by feeding back its output to the input through the *adjustable proportional-band network*, which determines how much of the output is fed back into the input; this adjustment is calibrated from 3 to 200 percent proportional band.

The proportional amplifier is a 3-stage a-c. amplifier with resistance-capacitance coupling, and self-bias on the second two amplifier stages, as shown in Fig. 6. The signal input from the primary-element transmitter is fed into the grid of the first amplifier stage, and the signal input from the set-point unit is fed into the cathode circuit. The output of the amplifier is fed back into the input through adjustable resistor R_5, and is mixed with the input signal by means of resistors R_1 and R_2.

Phase-Sensitive Rectifier

The output from the proportional amplifier goes to the phase-sensitive rectifier (Fig. 7), which converts this a-c. output into a proportional d-c. voltage. If the a-c. output from the amplifier increases in one polarity, the d-c. output of the phase-sensitive rectifier increases positively with respect to the ground (neutral) connection. If the a-c. voltage from the amplifier increases in the opposite polarity (that is, if the phase is reversed) the output of the phase-sensitive rectifier increases negatively with respect to the ground (neutral) connection. Therefore, the d-c. voltage output of the phase-sensitive rectifier is proportional to the difference between the signal voltage input and the set-point voltage input to the a-c. amplifier.

The operation of this circuit can be understood by breaking the basic circuit into several parts. The components shown in Fig. 7 (B) comprise a conventional shunt-rectifier circuit. Voltage E_1 is produced across R_{13} with the polarity indicated.

Next, consider the components shown in Fig. 7(C). Assume first that no input is applied to the signal terminal (a relatively low-impedance source). The reference a-c. voltage then produces d-c. voltage E_2 with the polarity shown. Application of an a-c. input to the signal terminal *in phase with the reference voltage* reduces the effective a-c. applied to the rectifier circuit, causing E_2 to be reduced. When applied *out of phase*, E_2 increases.

Thus, if these two circuits are combined as shown in Fig. 7(A), E_1 and E_2 are equal. The result is a phase-sensitive detector; variations in reference-voltage amplitude have no effect on accuracy.

The controller is changed from reverse to direct action by reversing the phase of the reference voltage to the phase-sensitive rectifier.

Rate Amplifier

The rate amplifier (Fig. 8) has a network that causes the d-c. amplifier to have an output that varies in proportion to both the magnitude and the *rate of change* of the signal input.

When no rate action is used with the controller, the rate amplifier has a voltage gain of one. This is obtained by feeding back the output of the d-c. amplifier to the input, thus reducing the normally high amplification.

When rate action is used, the output from the d-c. amplifier is fed back to the input through the rate network, which delays the feedback. For sudden changes in voltage input to the d-c. amplifier, the feedback action is delayed; consequently there is no feedback to reduce the normally high gain of this amplifier.

Fig. 8 shows the rate amplifier. Triode V_{2A} is a d-c. amplifier triode having a gain of about 50. The output from the plate is degeneratively fed back into the grid through resistor R_{15}. By choosing the values of R_{14} and R_{15}, the over-all gain of the amplifier can be made equal to minus 1. (It is *minus* because the output is inverted in phase with respect to the input.)

Battery "B" drops the voltage at the plate to a value suitable for feeding back into the grid of the tube. Grid resistors R_{14} and R_{15} are high compared to plate resistor R_{16} so that no appreciable current flows through battery "B." In the controller there is no battery; this voltage is derived from a floating power-supply unit.

To secure rate response, capacitor C_6 is introduced into the circuit. This ca-

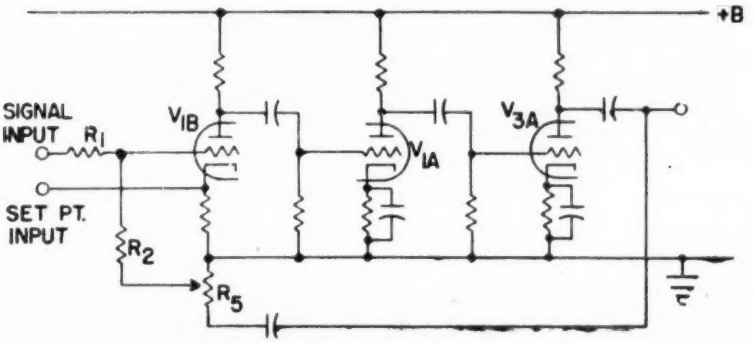

Fig. 6. Schematic diagram of proportional amplifier.

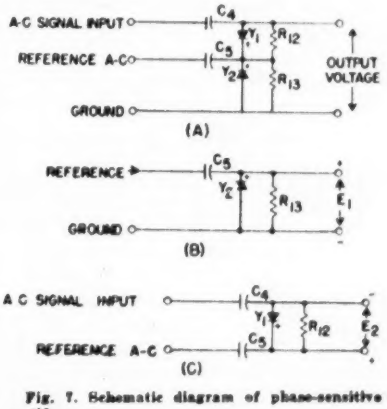

Fig. 7. Schematic diagram of phase-sensitive rectifier.

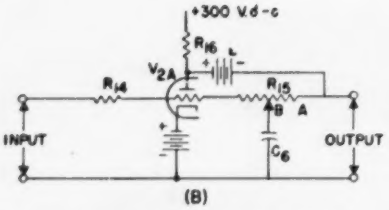

Fig. 8. Schematic diagram of rate amplifier.

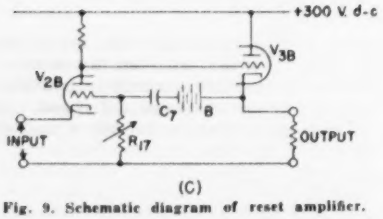

Fig. 9. Schematic diagram of reset amplifier.

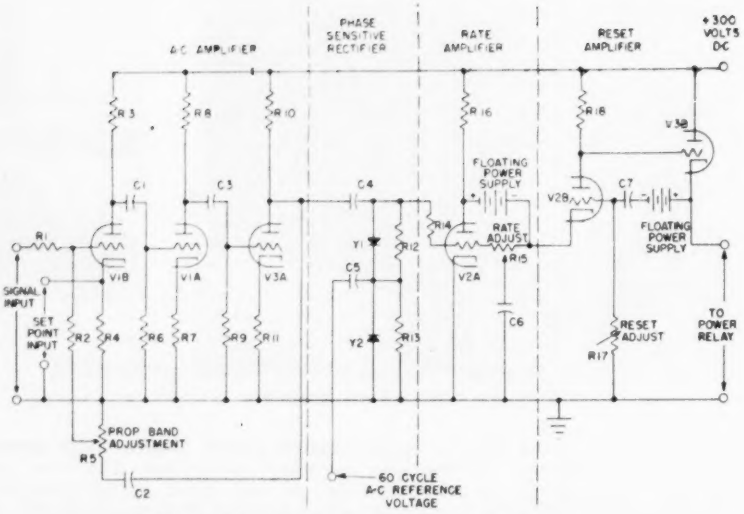

Fig. 10. Schematic diagram of "Autronic" controller.

pacitor, in combination with that portion of R_{15} between points A and B, interposes a time delay in the feedback circuit of the tube. This means that sudden changes in the input to the rate amplifier give greater output changes because capacitor C_6 shunts high-frequency components and reduces the negative feedback to the grid.

Reset Amplifier

The reset circuit (Fig. 9) gives a controller output proportional to the input and to the *time integral* of the input. This means that after sufficient time has elapsed, any value of output can be obtained with essentially zero input. Ideally, this unit should have infinite gain at d-c. and unity gain at high frequencies.

When the reset action is turned off, the controller output is fed back to the input of the reset amplifier. Under this condition the reset amplifier has an over-all gain of one.

When the reset action is turned on, the reset amplifier has an amplification of greater than 200 for steady-state or slowly-changing values of input. On more rapidly changing inputs, however, the reset network provides a transient voltage feedback which reduces the amplification. This provides the entire controller with an initially wide proportional-band effect on input amplitude changes. However, due to the characteristics of the reset network, this wide proportional band slowly reduces itself to a narrow proportional band. The rate of reset action is adjustable.

Referring to Fig. 9, V_{2B} is a voltage amplifier and V_{3B} is a cathode-follower power amplifier. Consider the operation of the circuit for a high-frequency signal. The signal is coupled back to the grid of V_{2B}. This is a degenerative feedback and hence the over-all gain of the amplifier is reduced to unity. For d-c. signal, however, capacitor C_7 prevents feedback from the output of the control into the grid and hence the amplifier has full gain. This means that only a small change in input voltage is now required to secure any value of output voltage. Ideally, we wish to obtain any desired value of output voltage with no change in input voltage. In practice, the gain of the amplifier is higher than 200, which means that the input need not develop more than ½ percent of the proportional-band setting. When reset is not used, capacitor C_7 is bypassed by a switch. This gives the circuit unity gain and requires inclusion of the dropping potential "B." Battery "B" is inserted for dropping the output voltage to a value suitable for feeding into the grid of the tube. As in the rate circuit, this voltage is obtained from a floating power-supply unit.

Mathematical Analysis of Controller

Fig. 10 is a schematic diagram of the controller. A block diagram of the controller is shown in Fig. 11. E_1 is the input voltage from the primary-element transmitter. E_2 is the set-point input voltage, and E_{12} is the controller output voltage to the power relay. The controller transfer function is shown in Fig. 11. It is the ratio of the output to the input, E_{12}/E_3.

The first term (K_0) is an over-all gain coefficient; its value is altered by changing the proportional-band setting

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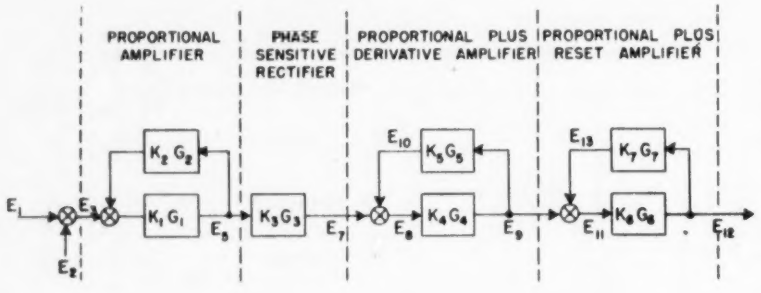

$$\frac{E_{12}}{E_3} = K_0 \underbrace{\left[\frac{1}{T_P j\omega + 1}\right]}_{(1)} \underbrace{\left[\frac{T_D j\omega + 1}{\left(\frac{T_D}{K_4 + 1}\right) j\omega + 1}\right]}_{(2)} \underbrace{\left[\frac{T_R j\omega + 1}{(K_6 + 1) T_R j\omega + 1}\right]}_{(3)} \underbrace{\quad}_{(4)}$$

Fig. 11. Mathematical expression of controller response.

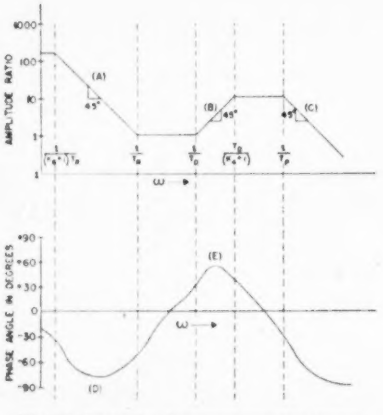

Fig. 12. Controller frequency-response curves.

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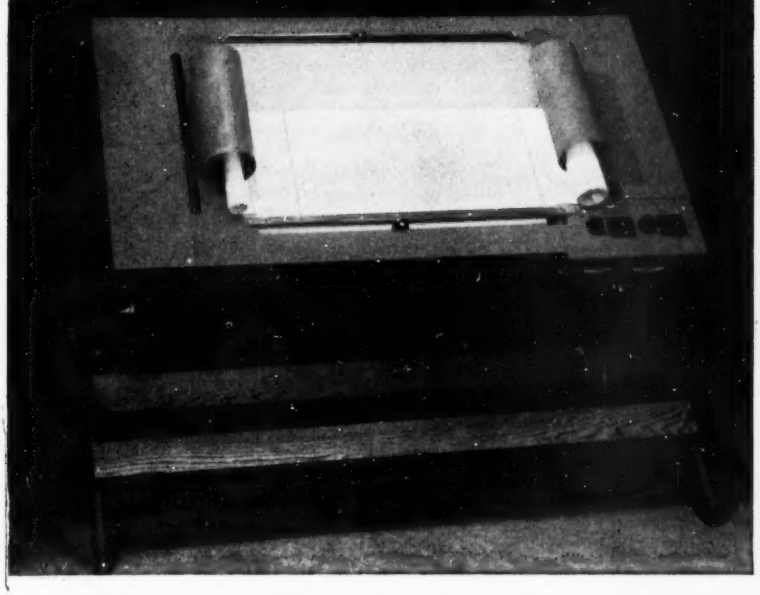

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Second Wednesday, Dinner at 6:30 P. M. Meeting at 8:00 P. M.
June 10 Pasadena Athletic Club-Banquet—6:30 Speaker: Ernest Silvertooth

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H. M. Messenger, 436 Sedgefield Rd., Charlotte, N. C.
Second Friday, Dinner at 7:30 P. M., Meeting at 8:30 P. M. Cardinal Restaurant, Charlotte, N. C.

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Thomas A. Carroll, 721 Hurlburt St., Peoria, Ill., Tel: 4-8909
Second Wednesday, Some dinner meetings at 6:30 P. M., Meeting at 7:30 P. M.

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Leon Stewart, Rock Island Refining Corp., P.O. Box 6091, Indianapolis, Ind. Tel: CO-2377
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Last Monday 8 P.M. U. of Houston Library May 25 Color Film "Principles of Automatic Control"

KALAMAZOO VALLEY
Jack M. Fettig, 433 Thomas St., S.E. Grand Rapids, Michigan.
Fourth Wednesday, 8:00 P. M., Dinner at 6:30 P. M. Meeting at Red Arrow Legion Post, 2431 W. Michigan Ave., Kalamazoo, Mich.

KANSAS CITY
Donald D. Baker, 5823 Mission Rd., Mission, Kansas
First Tuesday, Meeting at 7:30 P. M., U. of Kansas City, Science Bldg., Rm. 106.

LAKE CHARLES
A. T. Clinger, Columbia Southern Chemical Corp., P. O. Box 900, Lake Charles, La. Tel. 6-7522
First Wednesday after last Monday, Dinner and regular meetings at McNeese State College

LOUISVILLE
O. Vern Spousta, 2000 S. Brook St., Louisville, Ky.
First Monday, Meeting at 8:00 P.M., Seagram Auditorium.

MONTREAL
W. L. Toohey, Dominion Textiles Ltd., 1950 Sherbrooke St., West, Montreal, Tel. G1 5711
Last Monday of Month, Meeting 8:00 P.M., Mechanics Institute

MUSCLE SHOALS
Atherton Hastings, Tennessee Valley Authority, Div. of Chemical Engineering, Wilson Dam, Alabama. Tel: Sheffield 3160, Ext. 6238
First Thursday, Meeting 8:00 P.M., TVA Chemical Engineering Bldg.

NEW JERSEY
Eliot R. Hill, 1125 Kensington Ave., Plainfield, N. J.
First Tuesday, Meeting 8:00 P. M., Essex House Hotel, Newark, N. J.

NEW YORK
R. A. Hutcheon, 45-65 196th St., Flushing 58, N. Y., Tel: BAyside 9-5432
Third Monday, Dinner at 6:00 P. M., Meeting at 7:30 P. M., Midston House, 38th St. & Madison Ave.

NIAGARA FRONTIER
Duren L. Hagler, 214 E. Delavan Ave., Buffalo, N. Y., Tel: ELmwood 1258
Fourth Monday, Dinner at 6:00 P.M. Meeting at 8:00 P.M., N.Y.S. Technical Institute, 1685 Elmwood Ave., Buffalo, N. Y.

NORTH TEXAS
R. E. Byers, 6000 Lemmon Ave., Dallas 9.

NORTHERN CALIFORNIA
Robert L. Norman, 351 42 St., Richmond, Calif. Tel: BE 2-0901
Third Monday, Dinner 6:30 P. M., Meeting 8:00 P. M. Spengers Grotto, 1919 4th St., Berkeley.

NORTHERN INDIANA
M. J. Duzmal, 10504 Avenue "J", Chicago 17, Ill. Second Tuesday, Meeting at 8:00 P.M., Whiting Community Center, Whiting, Ind.

OAK RIDGE
Thomas M. Gayle, 117 W. Vanderbilt Drive, Oak Ridge, Tenn. Tel: 2-1516.
First Wednesday Meeting at 7:30 P.M., Ridge Recreation Hall

OGLETHORPE
J. R. Upson, 213 54th Street, Savannah, Georgia
Second Friday, 8 P. M. Reddy Kilowatt Room, Savannah Electric and Power Company, Savannah, Georgia.

PADUCAH
J. B. Russell, Carbide & Carbon Chemicals P. O. Box 748, Paducah, Ky. Tel: 5-6311—Ext. 403
Second Tuesday Dinner at 6:30 P. M. Meeting 8 P. M.

PANHANDLE
George W. Leggett, 1600 Western Ave., Amarillo, Texas
Third Tuesday, Dinner at 7:30 P.M. Phillips Grade School Cafeteria, Phillips, Texas

PERMIAN BASIN
Jack M. Ray, P.O. Box 1386, Odessa, Texas
Second Tuesday, Dinner at 8 P.M. Tel: 2-2813

PHILADELPHIA
A. S. Chatfield, c/o American Meter Company, 1513 Race St., Philadelphia 2, Pa.
Third Wednesday, Meeting at 8:00 P.M., Bellevue-Stratford Hotel.

PITTSBURGH
Dr. A. H. Peterson, Mellon Institute, 5500 Fifth Ave., Pittsburgh 13, Pa. MA 1-1100
Fourth Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Roosevelt Hotel

PRESQUE ISLE
Edwin P. Schuwerk, 445½ Halley St., L. P., Erie, Pa. Tel: 2-2349
Fourth Tuesday, Meeting at 8:00 P.M., G. E. Community Center, East Lake Rd., Erie, Pa.

RICHLAND
J. R. Plee, 1309 Roberdeau, Richland, Wash. Tel: 5-8692
Second Wednesday, Meeting at 7:30 P. M., American Legion Hall

ROCHESTER
R. C. Schwarz, Jr., 1201 Granite Bldg., Rochester 10, New York. Tel: Hamilton 1468
Fourth Tuesday, Meeting 8 P.M. U. of R., Bausch & Lomb Physics Lecture Room 109, River Campus

SABINE-NECHES
R. A. Block, 2301 Avenue "G", Nederland, Texas
Last Tuesday, Meeting at 7:30 P. M., Orange County Courthouse, Orange, Texas.

SARNIA
L. J. Hall, 730 Talfourd St., Sarnia, Ont., Canada. Tel: EDgewater 2258.
Third Monday, 8:00 P.M., Y.M.—Y.W.C.A.

SAVANNAH RIVER
F. P. Ledford, Jr., 907 Royalette St. N. Augusta, S. C., Tel: 5-4626
Second Wednesday, Dinner at 7:30 P.M. North Augusta Legion Post.

SEATTLE
Frank S. Melder, 2439 76th N.E. Bellevue, Washington
Second Friday.

SOUTH TEXAS
Homer C. Givens, P.O. Box 637, Falfurrias, Texas. Tel: 202
First Thursday, Engineers Club

ST. LOUIS
W. G. Lee, 4710 Delor St., St. Louis 16, Mo. Tel: FL 8516.
First Wednesday After First Monday, Meeting at 8:00 P.M., Engineer's Club of St. Louis.

TOLEDO
Howard R. Daily, 2025 Scottwood Ave., Toledo, Ohio.
Third Tuesday, Meeting at 8:00 P. M., Service Bldg., Toledo Edison Co.

TORONTO
John W. Huether, 311 Sutherland Dr., Leaside, Ontario, Canada. Tel: HU-7114
Fourth Thursday, Meeting at 8:00 P.M. Friendship Hall, College St. United Church, Toronto

TENNESSEE
James L. Williams, 2237 Bruce St. Kingsport, Tenn. Tel: 2079-L

TULSA
A. J. Sesock, 845 South East Ave., Tulsa, Okla., Tel: 8-1112
University of Tulsa Campus, Petroleum Bldg.
First Monday, Meeting at 7:30 P.M.

TWIN CITIES
John L. Schmidt, 1879 University Ave., St. Paul 4, Minn., Tel: DR 0064
Fourth Tuesday, Dinner at 6:30 P.M., Meeting 7:30 P.M., Rm. 363, Coffman Memorial Union, U. of Minn.

WASHINGTON
Edward C. Lloyd, 2105 Spencer Road, Silver Spring, Md. Tel: SH. 9340.
Third Monday, Meeting at 8:00 P.M., P. E. P. Co. Auditorium.

WAYNE COUNTY
Clarence Ellison, 2443 15th St., Wyandotte, Michigan. Tel: Avenue 2-4178.

WICHITA
J. W. Rieg, c/o Koch Engineering Co., Inc., 321 W. Douglas Ave., Wichita 2, Kansas

WILMINGTON
W. C. Ruglass, 900 A West 8th Street, Wilmington, Delaware

ISA NEWS

Chicago Host Committee Plans for Eighth National Instrument Conference and Exhibit

The Chicago Section Host Committee of the Instrument Society of America is busy planning for the Eighth National Instrument Conference to be held in Chicago September 21-25, 1953.

R. R. Proctor, General Chairman, together with the able assistance of M. D. Shriver and Adrian Hudson have the members of the Chicago Host Committee in full swing planning for the arrival of over 15,000 persons.

The Annual ISA party, to be held Wednesday, September 23, will be a gala carnival type party with continuous entertainment according to O. M. Haseltine, Chairman. This party is tentatively scheduled for the LaSalle Hotel.

Peggy Rutledge Dickson, Chairman of the Ladies Welcoming Committee has a group of Chicago ladies working hard on plans for a fashion show, tea, bridge parties, sightseeing trips and attendance at radio and television programs.

Final arrangements for the meeting rooms and the housing of those who plan to attend the Maintenance Clinic are being completed by Earl S. Bush and his committeemen.

The many details involved in carrying out a successful Host Committee program are being worked out by Charles Ament, P. E. Cary, J. H. Cuthbert, D. S. Dickey, J. T. Havens, George A. Larsen, J. B. McMahon and Charles Saunders in their various capacities as chairmen.

Two New Charters Granted

In April the Executive Board, upon the recommendation of the Sections and Membership Committee, approved by mail ballot Charters for two new Sections. The Oglethorpe Section, named after General James Oglethorpe, is located in Savannah, Georgia. The Wichita Section is located in Wichita, Kansas.

National Committees & Chairmen

Society Structure & Planning—Nelson Gildersleeve
Nominating—Ralph D. Webb
Constitution, Rules and Procedures—R. L. Galley
Instrument Industry—Charles L. Saunders
Finance—G. R. Feeley
Meetings & Exhibits—E. J. Grace, Jr.
Publications—C. W. Covey
Sections & Memberships—M. S. Jacobs
Employment—P. V. Jones, Jr.
Intersociety Relations—J. C. Peters
Public Relations—Douglas M. Considine
Government Relations—Ralph L. Goetzenberger
Educational—Prof. Robert J. Jeffries
Historical—L. M. Susany
Technical Program—E. G. Eskin
***Research and Development**—Chairman to be selected
Instrument Operation and Maintenance—J. Johnston, Jr.
Testing Instrumentation—D. C. Little
Analysis Instrumentation—Dr. Axel H. Peterson
Instrumentation for Inspection and Gaging—Thomas W. Marshall, Jr.
Instrumentation for Production Processes—C. A. Hansen, Jr.
Instrumentation for Transportation—John J. McDonald
Medical Instrumentation—Dr. H. J. Morowitz
Meteorological Instrumentation—Christos Harmantas
Radiation Instrumentation—Richard W. Johnston
Geophysical Instrumentation—S. Kaufman
Physical Properties Measurement—Prof. H. C. Roberts
Aeronautic Instrumentation—Robert Tozier
Data Handling—E. W. Burdette—R. P. Wehrle
Recommended Practices—A. V. Novak

ISA MEMBERSHIP REPORT
3/52—3/53

Section	Charter Date	3/52	3/53	Per cent Change
Akron	7/19/48	35	36	3
Albuquerque	7/16/49	45	44	–2
Aruba	1/24/47	39	31	–20
Atlanta	8/23/48	43	41	–5
Baltimore	1/10/46	104	133	28
Baton Rouge	5/10/49	20	35	75
Blue Ridge	1/28/53		40	
Boston	7/28/48	130	151	16
California	1/10/46	216	290	34
Carolina Piedmont	1/18/52	48	61	27
Central Illinois	3/ 8/48	33	31	–6
Central Indiana	1/30/47	85	87	2
Central New York	5/15/50	31	34	10
Central Ohio Valley	3/27/52	37	41	11
Charleston	1/10/46	84	96	14
Chicago	1/10/46	347	362	4
China Lake	1/17/49	22	15	–32
Cincinnati	3/ 7/47	79	90	14
Cleveland	1/10/46	137	182	33
Columbus	7/16/49	23	35	52
Cumberland	4/24/26	23	41	78
Denver	7/26/51	72	76	6
Detroit	1/10/46	62	67	8
Eastern New York	1/20/47	101	89	–12
Fox River Valley	9/ 7/52		52	
Houston	3/16/48	189	205	8
Kalamazoo Valley	11/11/46	28	29	4
Kansas City	1/10/46	69	72	4
Lake Charles	7/18/52		22	
Louisville	3/ 7/47	56	51	–9
Montreal	6/16/48	94	109	16
Muscle Shoals	6/17/52		45	
New Jersey	1/10/46	322	368	14
New York	1/10/46	276	288	4
Niagara Frontier	7/31/47	142	141	–1
North Texas	2/16/49	15	15	0
Northern California	9/10/49	106	74	–30
Northern Indiana	1/10/46	57	46	–19
Oak Ridge	8/27/46	89	84	–6
Paducah	1/28/53		126	
Panhandle	2/10/50	48	42	–12
Permian Basin	12/ 2/51	54	59	9
Philadelphia	1/10/46	358	395	10
Pittsburgh	1/10/46	270	292	8
Presque Isle	7/31/47	24	28	17
Richland	1/ 1/48	162	159	–2
Rochester	2/16/48	92	90	–2
Sarnia	9/ 1/47	110	103	–6
Sabine Neches	1/10/46	54	46	–15
Seattle	3/21/53		81	
Savannah River	3/27/52	45	82	82
South Texas	11/11/46	74	65	–12
St. Louis	1/10/46	123	127	3
Tennessee	1/10/46	58	58	0
Toledo	4/15/50	50	50	0
Toronto	1/10/46	37	43	16
Tulsa	9/ 6/47	131	117	–11
Twin City	3/10/47	45	45	00
Washington	1/10/46	149	152	2
Wayne County	1/10/46	169	153	–9
Wilmington	12/ 2/49	102	109	7
Foreign Members			32	
At Large		38	59	55
Corporate Member		1	1	0
TOTAL MEMBERS		5414	6223	11

Employment Service

PHYSICISTS AND RESEARCH ENGINEERS. The Physics Department of Southwest Research Institute has several permanent staff positions for physicists and research engineers with B.S. or advanced degrees, and 2 to 10 years of experience in acoustics, antenna design, electromechanical transducers, geophysics, nuclear physics, optical instruments, pulse circuits, or servomechanisms. Location: San Antonio, Texas. Box 801.

INSTRUMENT MECHANIC. Should have experience with pneumatic, electronic, and electrical recording and controlling instruments, be familiar with calibration, installation and maintenance of said equipment. Instrument experience in pulp and paper mill preferred. Location: Fernandina Beach, Florida. Box 808.

INDUSTRIAL INSTRUMENT MECHANICS. Must be experienced in the manufacture of Dial and Recording thermometers. Air, electric and self-operating Controllers, with mercury, vapor and liquid filled systems. Permanent and good pay for men who can get out the work. Location: Detroit, Michigan. Box 809.

Instrument Society of America

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Miniature Pressure Cells

By TAFT WRATHALL*

Abstract. High-speed aerodynamic testing requires the use of small pressure cells having good dynamic characteristics. Such cells usually employ a fixed-edge diaphram and make use of sensitive electronic detecting equipment. Construction details and general characteristics are given for three types of miniature pressure cells developed and used by the NACA. These three are resistive, capacitive and inductive. Buffeting and flutter research requires the measurement of fluctuating air loads so that with increased emphasis on this kind of testing such cells will play an increasingly important role as a research tool.

DURING the past few years the testing of high-speed airplanes has frequently required the measurement of dynamic pressures which on occasions extend into the middle audio-frequency range. Often structure shape or size necessitates that the pressure cells be very small. Usually such cells are constructed with a simple fixed plate for the diaphragm. Such construction lends itself well to a small unit, easy to make, and capable of measuring high-frequency pressures.

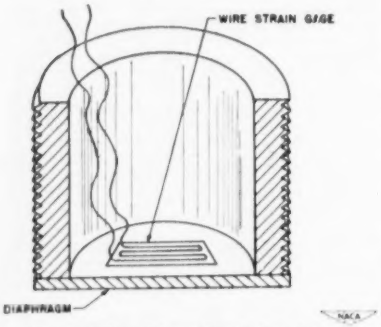


Fig. 1. Pictorial sectional drawing of strain-gage type pressure cell

Basically the measurement of pressure with such a device requires the detection of the diaphragm deflection. This deflection, being inversely proportional to the square of the natural frequency, is very low for high-frequency cells. For example, a ¼-inch diameter steel diaphragm designed to have a 25,000 cps natural frequency has a maximum deflection of 0.0002 inch when subjected to 10 psi pressure. To measure within one per cent, then, the associated equipment must be capable of detecting a change in deflection of 0.000002 inch.

*National Advisory Committee for Aeronautics, Ames Aeronautical Lab., Moffett Field, Calif.

Investigators, years ago, made cells having high natural frequencies, but their usefulness was limited because of inadequate detecting equipment. Because of the great improvement in electronic components and circuits during the past few years, the usefulness of such sensitive pressure detecting equipment has been greatly improved.

Fig. 2. Disassembled view of strain-gage type pressure cell

It is the purpose of this paper to show in general terms what has been done by the National Advisory Committee for Aeronautics in the development of small pressure cells. Construction details and characteristics are briefly discussed.

"Strain-Gage Type Pressure Cell"

In 1946 a buffeting research program was started at the Ames Laboratory, Moffett Field, California, in which small pressure cells for mounting in wing sections were needed. The frequencies to be measured extended up to about 50 cps, and an important part of the investigation was the determination of the pressure phase lag between various stations on the wing. To eliminate phase lag caused by pressure lines, which would confuse the results, flush cells were constructed. After considerable testing a design using a steel diaphragm was adopted.

Construction details of these cells are shown in Fig. 1. The diaphragm is heated by being placed on a hot plate and is then soldered around the edge to an unheated ring. By thus introducing an initial radial stress in the diaphragm, "oilcanning", or buckling is prevented and the gage output linearity is improved. The wire strain gage is cemented on the inside diaphragm face after the soldering operation.

Actual basic components used are

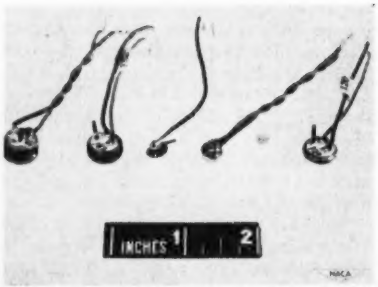


Fig. 3. Various models of the 1/2-inch and 1/4-inch-diameter strain-gage type pressure cells

illustrated in Fig. 2. The diaphragm and ring can be seen in the center. The wire strain gage is first trimmed around a pattern, the leads are then bent, and the gage is cemented with Bakelite cement inside the cell on the diaphragm face.

It has been found important that the paper base of the strain gage be cut to cover the entire diaphragm; otherwise objectionable hysteresis may occur. The back plate, on the left, is then soldered to the ring. This back plate has two small tubes which serve as connectors for the two strain gage lead wires and a larger tube for pressure connection from a static reference to the inside of the cell.

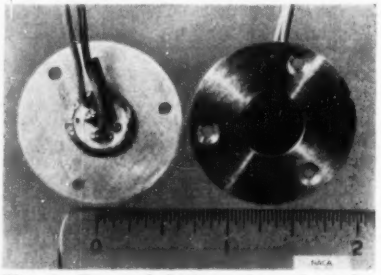


Fig. 4. Top and bottom view of strain-gage type pressure cell in mounting plate

Small Size Problem

Fig. 3 shows typical completed cells. Generally speaking, regardless of what kind of cell is made, design and construction problems become more severe as the size decreases. Dimensions become more critical and fabrication more difficult. For this reason the larger cells are used when possible. However, very small cells can be made when required.

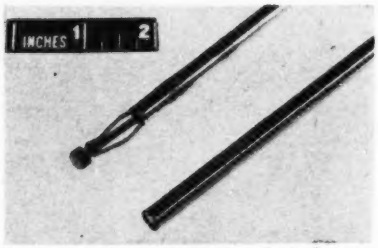


Fig. 5. Typical installation of strain-gage type pressure cell

Two sizes are shown having a number of construction variations depending upon the mounting requirements. The large ones are ½-inch in diameter and the small ones ¼-inch in diameter. The three half-inch cells shown differ primarily in the length of the body of the cell.

The left-hand cell and the one second from the right have straight pressure tubes; the other three have right angle tubes. The ¼-inch diameter cells have 5000 cps natural frequency diaphragms designed for measuring pressures to 5 psi. Cells of this type have been made for measuring from 1 to 20 psi.

Fig. 6. Two impact pressure tubes, using strain-gage type pressure cell as sensing head. One gage pulled away to expose wiring.

Designs for Installation

Special techniques, as illustrated in Fig. 4, are used in mounting to avoid stressing the diaphragm. The mounting plates have "cell mounting" holes which are oversize at the surface. This prevents transmitting strains from the mounting plate to the cell diaphragm. The space between the cell diaphragm edge and mounting plate is filled with a flexible material, such as rubber cement.

Fig. 5 is a typical installation. Over curved surfaces such as this the mounting plates are shaped to fit. In very thin models thin cells are used. Two small impact pressure tubes using these cells as the sensing element are shown in Fig. 6. The cell has been pulled out from one tube exposing the cell wiring.

The strain gage type cells are ordinarily used with carrier amplifiers. Instead of using a single cell as is normally done a number can be connected in series and the pressures summed, as is shown in Fig. 7.

Effects of Temperature

The maximum change in resistance of a 120-ohm gage, as used, is about 0.040 ohm. The changes in gage resistance and lead resistance with change in temperature are appreciable in comparison with the change due to pressure. Therefore, this type of cell is susceptible to considerable temperature effect on the static zero. The cells are particularly good because of their simplicity of construction and use, but, because of the zero drift, are used primarily for dynamic measurements.

A special electronic feed-back circuit which maintains a constant average output level has been designed into the carrier amplifier. This circuit, having a long time constant, accepts and neutralizes only slow d-c drifts. In this manner the zero drift has been considerably decreased.

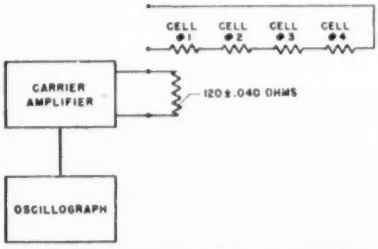


Fig. 7. Block diagram of carrier amplifier system used with strain-gage type pressure cell

Capacity Type Pressure Cell

Another type pressure cell used by the NACA has the same basic fixed diaphragm but instead of a strain gage on the diaphragm, measures the electrical capacity between the diaphragm and an internal fixed plate (Fig. 8). For a given natural frequency the sensitivity of such a cell, as measured by the change in capacity per unit pressure, is proportional to the square root of Young's modulus of the diaphragm, and inversely proportional to the square root of the density cubed.

On the basis of this relationship, magnesium alloys and glass were selected as diaphragm materials. Fortunately, these same materials are also preferred from a standpoint of temperature and acceleration effect.

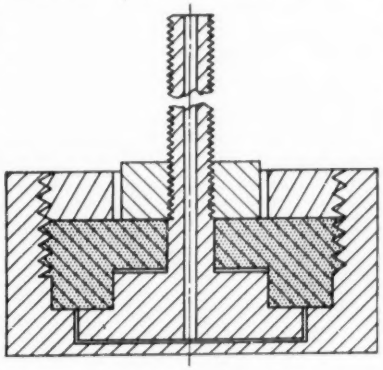


Fig. 8. Cross-sectional view of capacity type pressure cell

For the magnesium alloy cell, the body and diaphragm are machined from a single piece. One feature of the construction should be pointed out. The Microid insulator rests against both the shell seat and plug so that its expansion does not introduce a temperature error. In the actual cell (Fig. 9) the plug is held against the Microid insulator with one of the nuts shown. This combination is then held against the inside shell seat with the threaded ring shown at the right.

The thin, pliable washer shown alongside the threaded ring is placed under the ring to distribute the pressure evenly. Two nuts are used for making electrical connection to the center plate or plug. A bottom and top view of the assembled cell is also shown.

Machining of Diaphragm Important

The cell characteristics have been found to be closely tied in with the machining of the diaphragm. Careless machine work will leave a diaphragm with internal stresses and resulting poor temperature characteristics. Stress relieving at 400° F before and after machining has been found desirable. A number of cells were made by first machining the diaphragm to a thickness of about 0.008 inch.

Fig. 9. Exploded and two assembled views of flush capacity type pressure cell

This represents just about the minimum thickness machineable without backing up the diaphragm. The thickness was then further reduced by etching to 0.003 inch. This procedure minimizes the possibility of introducing internal stresses and is also particularly good where cells are to be matched for sensitivity, because they can be connected to their associated electrical measuring equipment while being etched and removed from the etching bath when the desired sensitivity is reached.

Doubled-Ended Capacity Type Cell

Whereas the magnesium cell is single-ended, a double-ended pyrex glass type cell was also made (Fig. 10). The main purpose of this design was to get a multiple-pressure measuring system as economically as possible. Forty of these cells were made at a cost of less than $1500.00. This cost also included power suppiy and detectors.

The cell itself consists of two glass backs with attached pressure leads and the glass diaphragm shown in the center. The remaining parts are for assembly. The inside face of each glass back is ground on a ½-inch diameter to a depth of 0.008 inch. The diaphragm is 0.005 inch thick. The inside surface of each back and both sides of the glass diaphragm are plated with a thin conductive layer.

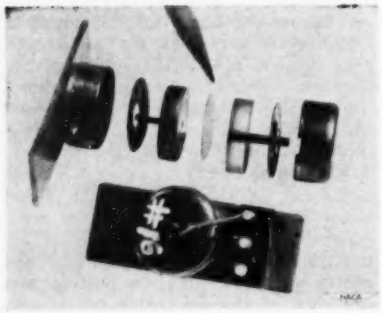


Fig. 10. Exploded and assembled view of double-ended capacity type pressure cell

Brass tubing is used for pressure and electrical leads. The two spring washers and metal case are made with punch and die. After the glass backs and diaphragm are assembled a circumferential wire loop makes contact with the diaphragm. The complete unit is mounted in a jig under pressure and soldered around the edge. A completed cell is shown at the bottom of Fig. 10.

Circuit of Capacity Cell

The capacity cells are used in a simple series circuit, so designed as to greatly minimize effect of line capacities and line capacity changes (Fig. 11). The only power consumed is in the condenser and cable dielectric and the load resistor, all of which losses can be kept small. Thus a large number of cells can be operated simultaneously from a single power supply.

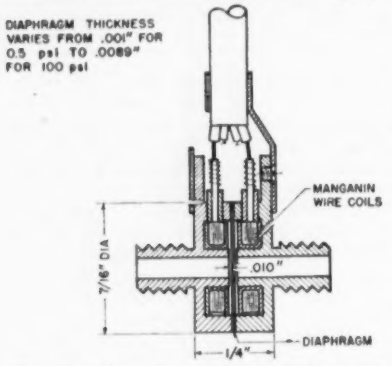


Fig. 11. Schematic measuring circuit used with capacity type pressure cells

The limits of power supply frequency are quite arbitrary, a higher frequency producing greater sensitivity. As noted in Fig. 11, we use 100 kilocycles. This same figure illustrates how summing pressures can easily be done by paralleling cells.

Fig. 12 shows a bank of magnesium alloy capacity cells of the type described. As can be seen they are connected in two groups of 11 each. Shielded lines can be seen at the right. As shown in the rear view they are connected so pressures in each bank of 11 are summed. Pressure lines have been removed from each cell to show wiring details.

Mounting on Wind Tunnel Test Body

Fig. 13 illustrates an interesting application of one of the cells mounted in a wind tunnel test body. An outside sleeve slides over the area including the cell and has a pressure orifice above the cell location. A Helmholtz resonator was formed by machining a depression in the test body with a passage connecting to the space above the pressure cell diaphragm.

By measuring the sound intensity generated by an air jet directed over the pressure orifice, it was possible to resonate the Helmholtz resonator with the cell acoustical chamber. The Helmholtz resonator frequency was changed by filling in the back end with wax. When the acoustical resonant frequency of the cell and the resonator were equal, the sound intensity was at

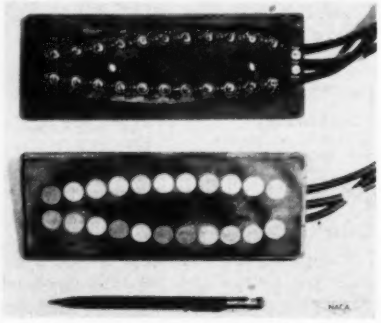


Fig. 12. Front and back view of bank of capacity type pressure cells

a minimum. This effectively lowered the Q of the cell acoustical chamber, thus permitting accurate measurement of pressures at higher frequencies.

Inductance Type Cell

A third cell developed by the NACA at the Langley Laboratory at Langley Field, Virginia, is a variable-air-gap inductance type which has had considerable use in wind-tunnel measurements of fluctuating pressure. This development is described in NACA Technical Note No. 2659 by John L. Patterson. It is a double-ended cell (Fig. 14) employing a stretched metallic diaphragm. The differential pressure across the gage deflects the diaphragm, and is measured as a change in the inductances of the two coils shown.

Excluding any leads, this cell has an outside diameter of 7/16 inch, a thickness of ¼ inch, and an active diaphragm diameter of 5/16 inch. A 0.010-inch air gap is maintained between the diaphragm and pole faces and agrees on both sides to within 0.0005 inch. All coils are of Manganin wire, wound with 150 turns within one turn and have the same resistance within one ohm. Glyptal cement is used to hold the coils in place and seal the lead-in wires.

The diaphragm must, of course, be of a magnetic material. In order to minimize changes in gage sensitivity with temperature, a low thermoelastic coefficient is also required, and the diaphragm and cell case should have the same small rate of expansion. Electrical considerations show that for maximum cell output and minimum effects of any variation in the magnetic qualities the cell diaphragm should have a high permeability. A 42 per cent nickel-iron alloy was found to best meet all these requirements.

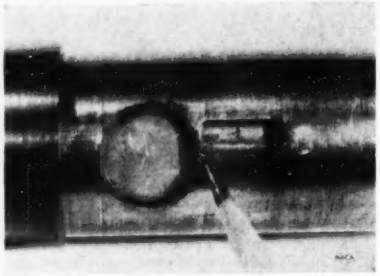


Fig. 13. Capacity cell and connecting Helmholtz resonator in tunnel test body

As in the case of the strain-gage type cell previously described, an initial radial stress put in the diaphragm improves the gage linearity and reduces the effects of small distortions often present in thin diaphragm materials.

Characteristics of Inductance Type

As would be expected, errors due to temperature are dependent, among other things, upon how well the coefficients of expansion are matched for the diaphragm and for the case material. The change in sensitivity with temperature where the materials are poorly matched has been found to be nearly ten times that in a well-matched cell.

As in other double-ended cells both the cell chamber acoustical resonance and the diaphragm frequency must be considered. A typical 8-psi gage has an acoustical frequency of 4100 cps and a diaphragm frequency of 14,000 cps. The diaphragm frequency, being considerably the higher, can usually be ignored. This same gage has a value of damping 11 per cent of critical.

For frequency measurements up to 300 or 400 cps these characteristics will assure good amplitude response

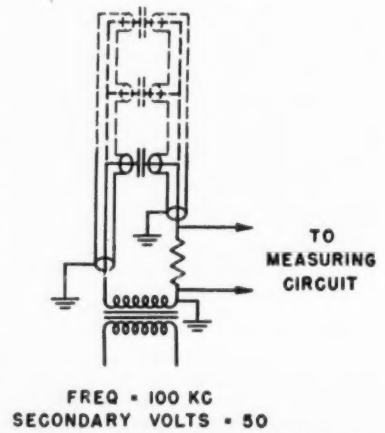


Fig. 14. Sectional view of inductive type pressure cell

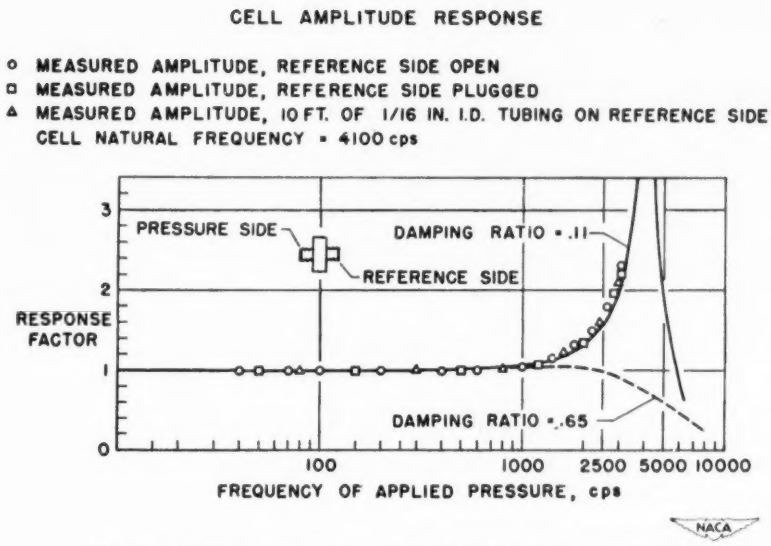

CELL AMPLITUDE RESPONSE
MEASURED AMPLITUDE, REFERENCE SIDE OPEN
MEASURED AMPLITUDE, REFERENCE SIDE PLUGGED
MEASURED AMPLITUDE, 10 FT. OF 1/16 IN. I.D. TUBING ON REFERENCE SIDE
CELL NATURAL FREQUENCY = 4100 cps
PRESSURE SIDE
REFERENCE SIDE
DAMPING RATIO = .11
DAMPING RATIO = .65
RESPONSE FACTOR
FREQUENCY OF APPLIED PRESSURE, cps
NACA

Fig. 15. Amplitude response curves for inductive type pressure cell

and low phase lag. In instances where higher frequencies must be measured, response characteristics can be improved by increasing the cell damping. Inserting one or more layers of closely woven silk or nylon cloth across the gage opening increases the damping to 65 per cent of critical. Curves in Fig. 15 show the improvement which can be expected with this higher damping. These curves also show that the cell response is unaffected by the type of reference pressure used.

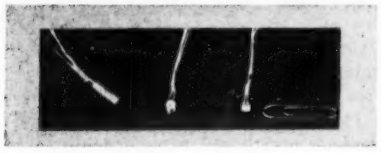


Fig. 16. Subminiature inductive type pressure cells

Variations of the standard 7/16-inch diameter cell have been made as shown in Fig. 16. These smaller units are used in certain applications where a particularly small size is needed. The right-hand model which is less than half the size of a regular cell has been used in the tip of several supersonic pressure survey probes and in small airfoil sections. The flush cell at the left built for shock-tube measurements has only one active air gap. The other gap is fixed using a silver shim to achieve better temperature compensation. These cells have a resonant frequency over 30,000 cps.

Typical Wind Tunnel Record

Fig. 17 is a copy of an actual record taken in a wind tunnel. The record is not unusual in any respect and is shown to illustrate a typical pressure record. This record was taken using a capacity type pressure cell. The timing lines are 60-cycle pulses. The predominant frequency is over 100 cps and some of the multiple frequencies

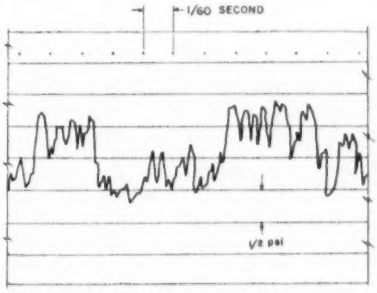


Fig. 17. Typical pressure time history taken with a capacity type pressure cell

are considerably higher. As can be seen some of the wave fronts are also very steep, requiring a high frequency cell for faithful reproduction.

Table I is a brief tabulation of the most important characteristics of these cells. In each case full scale is defined as the pressure at which nonlinearity reaches the value listed.

With greater emphasis in aeronautical research in the field of dynamic loads such as are found in buffeting and flutter, it is felt that pressure cells having good dynamic characteristics such as these described, will play an increasingly important role as research tools.

Table I. Characteristics of various miniature pressure cells.

Cell Type	* Non-Linearity	Resonant Frequency		* Temperature Effect		* Acceleration Effect	Input Power (Watts)	* Hysteresis
		Chamber (cps)	Diaphragm (cps)	Zero Drift	Sensitivity			
Resistance	2.0	———	8300 (½psi)	0.5	0.025	0.02	0.13	2.0
Flush	2.0	———	2300 (¼ psi)	0.5	0.025	0.02	0.13	2.0
Capacity Flush	2.0	———	25,000 (2 psi)	0.4	0.04	0.015	<0.0001	<0.03
Double Ended	1.0	4,000	9800 (8 psi)	<0.005	0.33	0.006	<0.0001	0.6
Inductive	2.0	———	30,000 (8 psi)	0.05	0.05	0.004	0.1	1.0
Flush	2.0	———	90,000 (150 psi)	0.05	0.05	0.004	0.1	1.0
Double Ended	1.0	4,200	10,000 (1 psi)	0.02	0.03	0.013	0.2	0.7
	1.0	5,800	43,000 (200 psi)	0.02	0.03	0.013	0.2	0.7

*Per Cent of Full Scale

The Pneumatic Refractometer
A Continuous Fast Recording Gas Analyzer

By DR. H. G. CLAMANN*

Abstract. The refractive index of a pure gas varies with its density or, in a mixture of gases with components of different refractive indices, with its concentration. The gas mixture to be analyzed is forced by constant flow to form a well defined band imbedded in a suitable reference gas. A light beam passing from the reference gas into the analyzed gas is refracted according to changes in its composition, therefore more or less spread out, thus changing the brightness of an image. These changes are transmitted by photocell and amplifier to an indicating or recording device.

OF all the various physical properties of gases which can be utilized for the construction of gas analyzers, little use has been made of the index of refraction of light. The only type of instrument based on this principle, so far, is the interferometer. Its general applicability to gas analysis, its high accuracy and sensitivity, make it an excellent laboratory instrument. However, the weak fringe system of its interference pattern permits subjective observation only. Futhermore, pressure and temperature must be kept very constant.

The simplicity of the physical laws which govern the relationship between the index of refraction and the concentration of gases is too tempting to pass up the chance to try other ways for its utilization. An attempt has been made in this direction in the construction of a new instrument for gas analysis, which is called the *Pneumatic Refractometer.*

Optical Principles

Before details of construction of the Pneumatic Refractometer are given, optic principles upon which it is based will be described. If a ray of light, originating in a vacuum, passes into any kind of transparent medium, its velocity is slowed down to a rate depending upon the substance and the frequency of the light. If a ray of light travels from one medium into another rather than from a vacuum, it is possible that the relative velocity in the second medium is higher than in the first one. The medium in which the velocity of light is lower is known as the *denser* and the other medium is consequently called the *rarer.* This

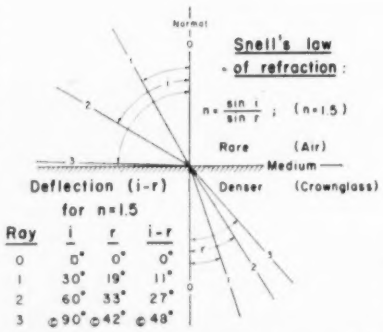


Fig. 1. Snell's law of refraction illustrated.

change in velocity of the ray of light causes a deviation or refraction in its direction, if the ray strikes the flat boundary between two media of different density in an angle between 9° and 90°. Traveling from a rarer into a denser medium, the ray is refracted toward the vertical or normal, and vice versa.

This is stated by Snell's law of refraction:

$$n = \frac{\sin\ i}{\sin\ r}$$

where n is the index of refraction, i the angle of incidence, and r the angle of refraction.

For the pair of media, air and crownglass, (Fig. 1) for instance, n equals 1.5. It may be noted also that the deflection of a ray of light from its original path equals $(i - r)$ and is greatest when i approaches 90°. Actually, because the refractive index also represents the ratio between the velocities of light in two different media, one may write:

$$n_l = \frac{v_o}{v_l}$$

where v_o is the velocity of light in vacuum, v_l the velocity of light in a medium m_l; the same is valid for a medium m_s:

$$n_s = \frac{v_o}{v_s}$$

If the light passes from m_l into m_s, the resultant refractive index n_R would be:

$$n_R = \frac{v_l}{v_s}$$

or, substituting v_l and v_s by the equations for n_l and n_s:

$$n_R = \frac{n_s}{n_l}$$

Thus one can find the refractive index for a light beam passing from a medium m_l into another medium m_s (symbolized $m_l \rightarrow m_s$) the indices of which are given as usual in reference to vacuum.

In Fig. 2 the refractive indices are thus evaluated for (1) air → crownglass: $n = 1.5$; (2) air → water: $n = 1.33$; and (3) air → carbon dioxide: $n = 1.000158$. The angle of refraction r is plotted against the angle of incidence i, the latter ranging from 0° to 90°. If i is kept constant, sin r as well as r itself vary inversely with n.

Conclusions Derived from Principles

Taking the aforementioned pairs of media as typical examples for solids, fluids and gases (in general) in reference to air, three facts are evident:

(1) The refractive index between gases is very small compared to solids and fluids.

(2) A noticeable deflection of a light beam between gases is obtained only at high angles of incidence.

(3) At a constant angle of incidence, the deflection $(i - r)$ of a light beam varies directly with the index of refraction.

In gases, as in solutions, the index of refraction varies directly with the concentration. Hence, in pure gases the index of refraction varies directly with pressure and temperature. Strictly speaking, this is valid for $n - 1$ instead of n in order to eliminate the unit 1.

$$n_{p,t} = \frac{n_{760,o} - 1}{1 + dt} \times \frac{p}{760}$$

where: n = index of refraction

t = temperature (°C)
p = pressure (mm Hg)
d = coefficient of expansion of gases (.00367)

*Department of Physiology and Biophysics USAF School of Aviation Medicine, Randolph Field, Texas.

*Presented at the Seventh National Instrument Conference and Exhibit held in Cleveland, Ohio, September 8-12, 1952.

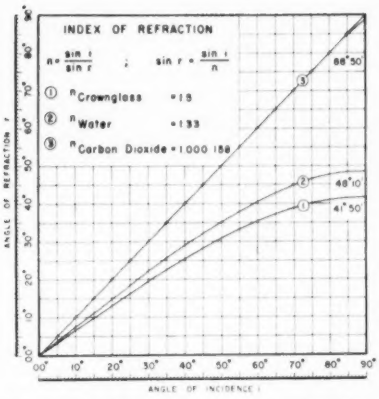


Fig. 2. The function: r = f (i), given for crownglass, water and carbon dioxide, with air as reference gas. The number of degrees given on the end of each curve indicates the highest possible value for r, with i = 90°.

In mixtures of gases, excluding chemical interaction between the components, the refractive index of each component varies directly with its partial pressure or part of volume. The resultant refractive index n_R in a mixture of various components with the refractive indices $n_1, n_2 \ldots n_n$ equals:

$$n_R(v_1 + v_2 + \ldots v_n) = n_1v_1 + n_2v_2 + \ldots n_nv_n$$

$$n_R = \frac{n_1v_1 + n_2v_2 + \ldots n_nv_n}{v_1 + v_2 + \ldots v_n}$$

where: n_R = resultant index of refraction
$n_1 n_2 n_n$ = indices of components 1,2,n
$v_1 v_2 v_n$ = volumes of components 1,2,n

These statements about the refractive index in general and its behavior in gas mixtures in particular already show the essential principles for the construction of the Pneumatic Refractometer, namely:

(1) In order to obtain, for the purpose of measuring the refractive index, the highest and most undisturbed deflection of a ray of light by a gas (or gas mixture), the ray of light has to strike an optically plane boundary directly between the gas to be measured and a suitable reference gas, avoiding any intermediate glass wall, or another transparent medium of a high index of refraction.

(2) The deflection obtained has to be transduced into an electrical signal.

Construction of Pneumatic Refractometer

In the Pneumatic Refractometer the boundary between the gas to be analyzed and a chosen reference gas is obtained by a constant laminar flow of both gases (Fig. 3). The reference gas, usually plain air, is drawn by the suction of a small vacuum pump through the analyzing cell and forced to form a laminar stream by a wire mesh (represented by the perforated

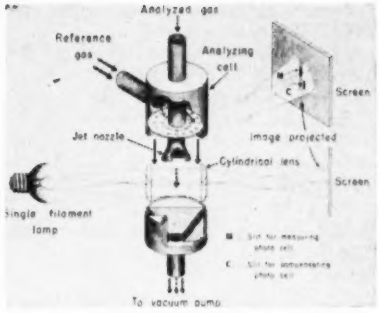


Fig. 3. Schematic diagram of Pneumatic Refractometer. The image is though as caused by a sampling gas denser than air (dark band), covering the slit M.

disc in Fig. 3). The cell inside, shaped like a Venturi-tube, provides suction to a very small slit-like jet nozzle.

The analyzed gas enters the cell through this nozzle in the form of a well-defined small band, imbedded in the reference gas. The speed of the gases in the range of meters per second and their aforementioned laminar flow, prevents any disturbing diffusion between the gases across the boundary at the small distance of 10 mm, where they are traced by the analyzing light beam.

A cross section of this optic arrangement (Fig. 4) shows its function more in detail. The analyzing light beam is generated by a straight (single) filament lamp (S). The light enters the cell through a cylindrical lens L_1, the axis of which is parallel to the filament and to the band of the analyzed gas. Thus, the light beam forms a slightly convergent bundle, striking the gas band and leaving the cell through a second cylindrical lens L_2 toward a screen.

In the absence of an analyzing gas, an image of uniform brightness (I) is formed on the screen, represented by equal distances of the rays of light *1* to *5*. If a gas "denser" than the reference gas enters the cell, the rays *2*

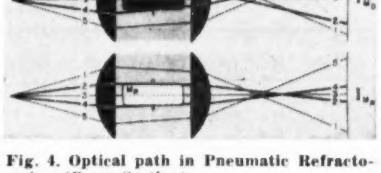


Fig. 4. Optical path in Pneumatic Refractometer (Cross-Section).
S: Light source
L_1, L_2: Cylindrical lenses
SC: Screen
I: Image without a sampling gas
I_{MD}: Image of a sampling gas, denser than air (MD)
I_{MR}: Image of a sampling gas, rarer than air (MR)
The little arrows indicate the point, where the light rays 2 and 4 strike the band of the sampling gas

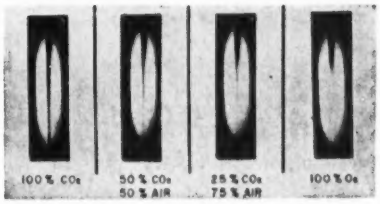


Fig. 5. Images in the Pneumatic Refractometer resulting from various gas mixtures.

and *4* striking its surface are refracted toward the centerline. These rays are diverted from the middle toward the periphery of the screen, so that a dark band is formed on the screen, framed by two brighter zones (I_{MD}). In the case of a rarer reference gas, the opposite image is created: a bright band framed by darker marginal zones, (I_{MR}).

In both cases, referring to the aforementioned relationship between concentration and refractive index, the angle of refraction varies directly with the concentration, the angle of incidence being constant. For the same reason, the width of the band, dark or bright, on the screen varies directly with the deflection, and so does the brightness of a given area within the band. This is illustrated (Fig. 5) by

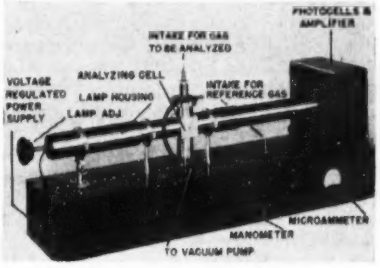


Fig. 6. The Pneumatic Refractometer assembly.

images resulting from pure carbon dioxide and air in various concentrations, but still denser than the reference gas, room air. 100 per cent oxygen is shown as a sample for a gas rarer than air.

Photocell Produces Electric Signal

For the final recording, there is a small slit M in the screen, (see Fig. 3), smaller than the smallest image of a band obtained for the lowest concentration which is expected to be recorded; this small slit is for the purpose of screening out the marginal zones of the image. A photocell behind this slit thus receives an illumination which is proportional to the gas concentration. A second photocell behind another slit C outside of the image, but within the illuminated field, is coupled with the first one in a bridge circuit. Thus, changes in brightness of the light source are counterbalanced.

The electrical signal from the photocell circuit is finally amplified by a one-stage d-c push-pull amplifier and fed either to a microammeter or a recording galvanometer. Fig. 6 shows

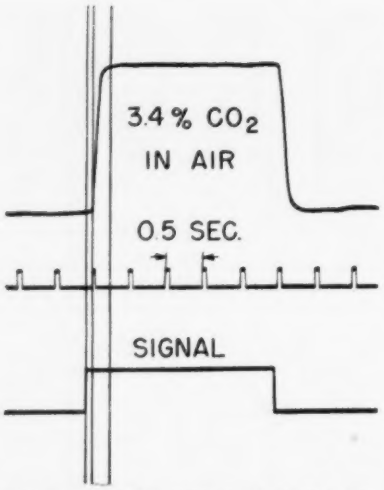


Fig. 7. Calibration curve in Pneumatic Refractometer. Beginning and end of signal indicate flow of the calibration gas mixture. The distance between the first vertical line (at left) and the second line marks the latency time; the distance between the second and the third line, the response time.

how these parts are built together to the complete apparatus, including a voltage regulated power supply.

Curves Obtained

The performance of the present model of the Pneumatic Refractometer is demonstrated by some curves as they were obtained in respiratory studies. Figs. 7 and 8 show results of calibration tests with various mixtures of air and carbon dioxide and indicate the fast response and the latency time (the latter limited mainly by the dead space of the connecting tubes). Fig. 9 also demonstrates that pressure changes alone, as they occur during inspiration, do not influence the recording. As for carbon dioxide in air, the accuracy will be about 0.1 per cent.

These curves show how a gas component, CO_2, with a sufficiently higher refractive index than the two other components, O_2 and N_2, can be measured if the ratio of these components remains nearly the same. The quantitative relationship between the refractive indices of these gases, with air as a reference gas, is given in Table I. First, the resulting refractive indices and $n-1$ values are computed as aforementioned.

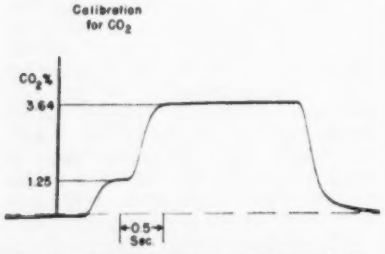


Fig. 8. Calibration curve of Pneumatic Refractometer. The flow of the calibration gas mixture is switched from a lower (1.25%) to a high concentration (3.64%) within 0.2 seconds.

3.5 times higher, but here toward the other side as indicated by a minus sign. The $n-1$ values of gases like nitrous oxide or of hydrocarbons starting with methane are up to 5 times higher than CO_2, and vapors of methyl and ethyl alcohols, chloroform and benzene are of the same magnitude; thus it is obviously easier to measure these gases and vapors than CO_2.

Referring to the galvanometer deflection obtained on N_2 as *unit 1 (Ratio)*, it can be seen that on CO_2 the deflection is 26.3 times higher, and O_2,

Some Limitations of System

The difficulty starts, as for any non-specific gas analyzer, in measuring a three or more component mixture, the components of which have nearly the same refractive index. Here samples containing each of the components in different proportion can yield the same measured value. In this case, the system must be reduced to a two-component system by eliminating one undesirable component. The use of twin jets, each of which is fed by another group of components, may also be helpful. Such a model is at present under construction.

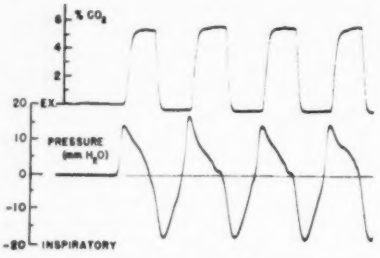


Fig. 9. Record of the rapid changes of CO_2 concentration (upper curve) as they occur in the expired air during respiration, using a mouthpiece. The lower curve shows the positive and negative pressure changes in the mouthpiece, to demonstrate the synchronism between expiration period (positive pressure) and presence of CO_2.

Certain possibilities on the optic side toward a specific response have been planned, but not yet used. As mentioned in the beginning, the refractive index increases with decreasing wave-lengths, and this variation is known as *dispersion*. Discontinuities in the dispersion curves occur in regions where an absorption band exists (Fig. 10). Here, the refractive index is lower than normal on the violet side and higher than normal on the red side of the absorption band, thus causing *anomalous dispersion*. By use of a suitable filter, which transmits only those frequencies on the red side of the absorption band, it would seem possible to enlarge the refractive index for a certain component in a gas mixture.

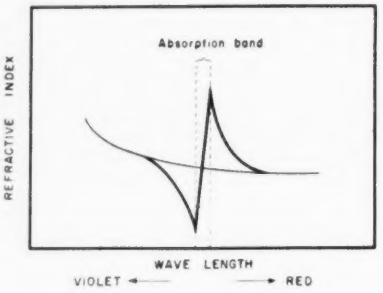


Fig. 10. Graph illustrating anomalous dispersion.

So, as described in this paper, the principle of the Pneumatic Refractometer seems to have possibilities for further development, even for refractometric measurements on liquids. To indicate these possibilities, rather than to show an apparatus developed to its latest details, is the purpose of this paper.

Summary

(1) The Pneumatic Refractometer is a non-specific gas analyzer. It permits fast and continuous recording of all gas mixtures, the components of which have different refractive indices.

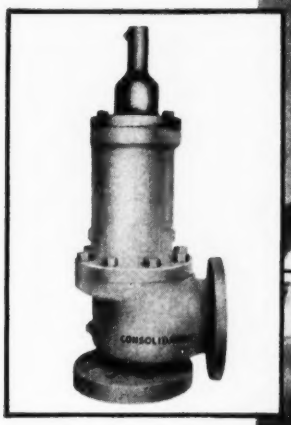
(2) The fact that the measurement is based on a ratio between a reference and an analyzing gas, excludes, to a great extent, disturbances from pressure and temperature.

(3) The Pneumatic Refractometer possesses a high degree of versatility because of its simple construction and the simple laws on which its principle is based.

Table I: Ratio of (n-1) obtained on various pairs of gases in Pneumatic Refractometer.

"Gas to be analyzed / "Reference Gas		Resulting Refractive Index	$n-1$	Ratio
CO_2 / Air	1.000 450 / 1.000 292	= 1.000 158	+ .000 158	26.3
N_2 / Air	1.000 298 / 1.000 292	= 1.000 006	+ .000 006	1
O_2 / Air	1.000 271 / 1.000 292	= 0.999 979	— .000 021	3.5

ALWAYS ALERT TO DANGER . . .



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Instrument Evaluation By

FREQUENCY RESPONSE

By BEN D. STANTON

Shell Development Company, Emeryville, California

Frequency-response techniques for testing automatic-control components are used in the petrochemical industry. The types of tests and the instruments required to conduct these tests are described. Methods used to calculate the transfer functions from the frequency-response data, and several typical frequency-response curves are explained.

ANALYSIS of instrument performance can be divided into two components: static and dynamic. Static refers to the steady state, with no response upsets. Dynamic refers to the transient recovery following load or set-point changes. One method used to determine dynamic performance is the frequency-response test. This test, as first used in the design of electronic amplifiers, was a simple measurement of output level as a function of input frequency, and was limited to describing the bandwidth or frequency coverage. It was made applicable to automatic-control problems, particularly in the application of electric power, by including the measurement of output phase lag or lead relative to input. These results enabled the design engineer (1) to compare the response of similar components, (2) to combine them most effectively into control systems, and (3) to determine the effectiveness of the control system both with respect to dynamic recovery and steady state stability, the latter also being a function of gain and phase shift. With these design techniques enjoying wider use in the automatic control field it was only a matter of time until the process-control engineer began investigating his systems by the frequency-response method.

It was soon realized that for the optimum design of systems to control processes such as oil refining and the manufacture of chemicals, the components (transmitters, controllers, and control valves) should be evaluated by a test for frequency response. To obtain test data for use by the field engineer, Shell Development Company has included frequency response in the list of tests performed on commercial control instruments. The test results are disseminated to aid in selection of components and design of systems.

Test Equipment

The frequency-response test requires special test instruments, including a sine-wave generator and a multichannel recording system. Any test instrument should have dynamic characteristics which exceed in range those of the instrument being tested. The generator to test commercial pneumatic control-

June Meeting: Thursday, the 18th, Rio Hondo Country Club, Downey, Calif.

Feature: Mr. Forest H. Wehrman, Grove Regulator Co., will present a paper on "Pressure Regulation and Flow Control."

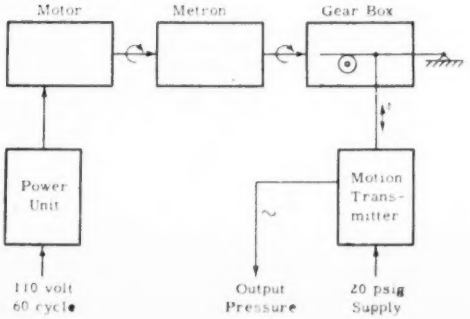

Fig. 1. Pneumatic sine-wave generator.

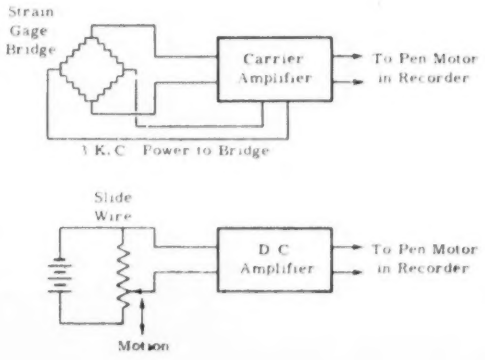

Fig. 2. Measurement systems using carrier and d-c. amplifiers.

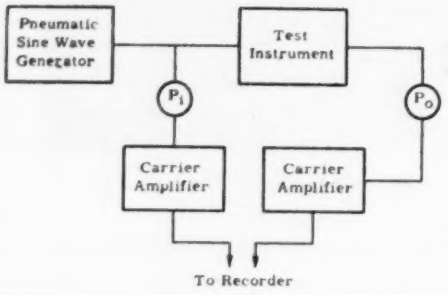

Fig. 3. Frequency-response test setup.

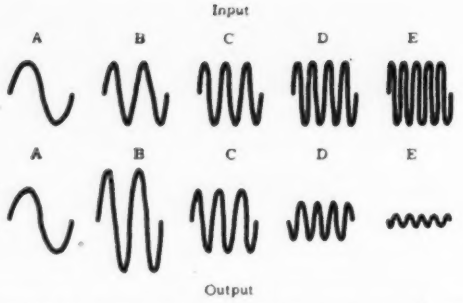

Fig. 4. Frequency-response data.

system components should produce pneumatic sine waves of variable frequency with a range between 1 cycle per hour and 20 cycles per second. The amplitude of the signal should be continuously variable from ¼ psig. to 9 psig. The average signal level should be continuously variable from 0 to 20 psig. As a sine-wave generator to meet these requirements was not commercially available it had to be built (Fig. 1), using a variable-speed motor, a gear box, an eccentric, a scotch yoke, and a pneumatic motion transmitter.

An electronic-type recording system is desirable because of its high speed of response and the ease with which zero and span can be varied. The recording system consists of transducer pickups feeding signals into amplifiers (either carrier or d-c. type) which operate pen motors; the pens write on a variable-speed strip chart (Fig. 2). Carrier amplifiers have high gain and stability, which is necessary when using strain-gage and bridge-type pickups. Both the d-c. and carrier amplifiers have calibrated zero-shift dials, and attenuators to change the span.

To convert pressure, temperature, and mechanical signals to electrical signals, strain-gage-type pressure gauges, resistance thermometers, and potentiometers are used, as shown in Fig. 2. Strain-gage transducers are desirable because of their high speed of response and the small input volumes, which present small load to the instrument being tested. Resistance thermometers also present small loads and give fast response because of their low mass; they also have high sensitivity. The potentiometer is used to measure mechanical motion by connecting the shaft through a linkage to the moving part and applying a d-c. voltage across the potentiometer. As the shaft is rotated by the mechanical motion, the voltage input to the d-c. amplifier varies.

Test Methods and Procedure

The procedure for testing a commercial flow transmitter illustrates the test principles. The transmitter measures differential pressure across an orifice and transmits a pressure signal (which is a function of flow) to a controller. Fig. 3 shows the test setup for a typical pneumatic flow transmitter which has an input differential-pressure range of 0 to 100 inches of water for an output of 3 to 15 psig. To test this instrument, the low-pressure side of the transmitter is vented to the atmosphere and the high-pressure side is connected to the sine-wave generator and to a 4-psig. Statham pressure transducer (P_i). The sine-wave generator is set to develop a signal with a peak-to-peak pressure amplitude of 20 inches of water at an average pressure value of 50 inches of water. A 20-psig. Statham gage (P_o) is placed in the output of the transmitter. The Statham gages are connected to carrier amplifiers which are in turn connected to two pen motors in the recorder.

Before the sine-wave test is started, the input signal is varied over the test range of 40 inches to 60 inches of water, and the amplitude of this change is recorded. At the same time the output signal, which varies from 7.8 to 10.2 psig., also is recorded. From these two amplitudes the zero-frequency amplitude ratio (output divided by input) is determined.

The signal generator is then started and the frequency increased in steps, producing input and output signals (Fig. 4). At low frequencies the input and output signals maintain their zero-frequency amplitudes and no phase shift is apparent. However, as the frequency is increased, the amplitude of the output signal first increases and then decreases rapidly. At each frequency the output amplitude is divided by the input amplitude to obtain the amplitude ratio. As the output amplitude starts to change, it also begins to lag behind the input; as the frequency is increased this lag becomes larger. From this lag, phase shift can be calculated. Fig. 5 shows how the amplitude ratio and phase shift are calculated.

Presentation of Frequency-Response Data

The test data—amplitude ratio, phase shift, and frequency—are plotted in two forms: the rectilinear form called the *Bode diagram*, and the polar form called the *Nyquist diagram*. The Bode diagram (Fig. 6) is a plot of log frequency vs. log amplitude-ratio, and log frequency vs. phase shift in degrees. The Nyquist diagram (Fig. 7) is a plot of frequency vectors, with the amplitude ratio as the vector length and the phase shift as the angle of rotation. As the Bode diagram presents the most information and is the popular form, it is explained in detail. For each frequency the ratio of output to input amplitude (AR) is converted into decibels by use of the formula:

$$db = 20\ log_{10}\ (AR).$$

The phase lag (ϕ) is measured for each frequency and converted to degrees by use of the formula:

$$\phi = 360\ t_1/t_2,$$

where t_1 is the time lag between input and output, and t_2 is the time for one cycle (Fig. 5). These are plotted in curves of phase shift (ϕ) and amplitude

Amplitude Ratio (AR) = $\frac{A_{out}}{A_{in}}$

Decibels (db) = 20 $\log_{10}$ AR

Phase Shift (ϕ) = $\frac{360 \times t_1}{t_2}$

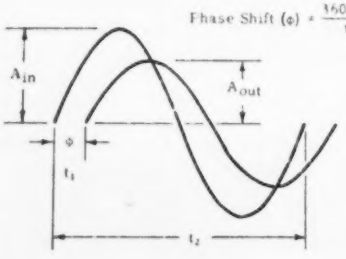

Fig. 5. Test data.

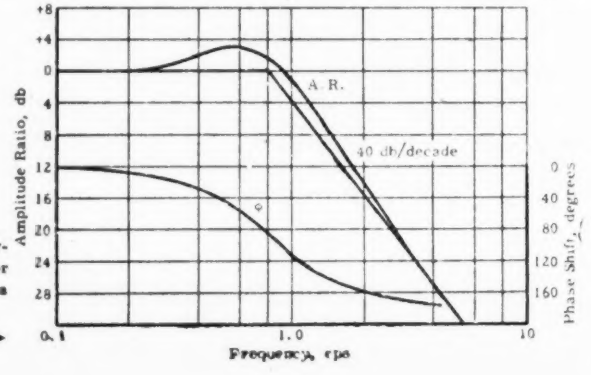

Fig. 6. Frequency-response curves, or Bode diagram, of a flow transmitter.

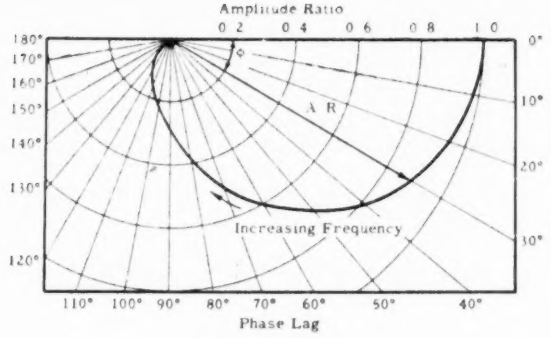

Fig. 7. Nyquist plot.

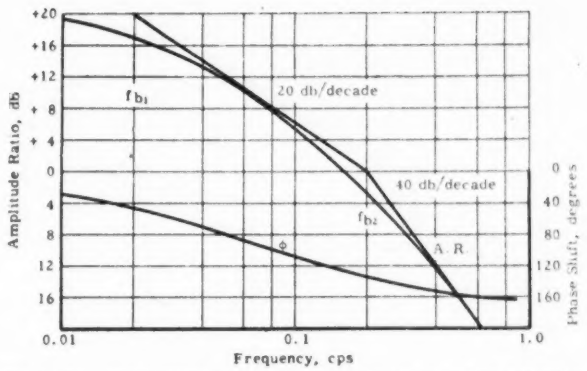

Fig. 9. Frequency-response curves for a system made up of two first-order units.

ratio (AR) vs. frequency, as shown in Fig. 6.

Interpretation of Bode Diagram

From the curves in Fig. 6 it is possible to determine the time-constant of the system, the order of system tested, the damping factor, and the frequency coverage.

The system is a first-order system when the quantity changing with time appears in the differential equation in its first time derivative, but not its second; the system is of second order when the second derivative appears, with or without the first. A practical example of a first-order system is a needle valve and a volume tank; a simple example of a second-order system is a spring and mass. If a step-type disturbance is placed on the input of a first-order system the output comes to a new value in an exponential manner, the time required to reach 63 percent of the final value being numerically equal to the time constant. The second-order system, however, normally recovers from a step-type disturbance in an oscillatory manner. This may be illustrated by hanging a mass on a spring and then quickly moving the upper end of the spring. Before the mass comes to rest in a new position it will have described several oscillations.

The magnitude and duration of the oscillations of second-order systems are determined by the *damping factor*. If the spring and mass are in oil, the oscillations for a given input change would be smaller than those observed in air. This means there is more damping, or a higher damping factor, in oil. It is interesting to note that first-order systems do not have damping factors, and that second-order systems may have high damping and consequently no oscillatory recovery. In second-order systems the time constant and the damping factor together determine the speed of response, large values of each resulting in slow response. In such systems the time constant has a simple physical meaning (period of oscillation) only when damping is small.

The frequency-response curves indicate the system's order by the slope of the AR curve and the maximum phase shift. For each first-order time-constant there will be a maximum phase shift of 90 degrees, and an AR slope of 20 decibels per decade; for each second-order time-constant a maximum phase shift of 180 degrees and an AR slope of 40 decibels per decade. (A decade is a range of frequencies having a multiple of ten, such as 3 to 30 cps.)

Data obtained on the flow transmitter (Fig. 6) indicates that the time constant is second order because the phase shift approaches 180 degrees, and the slope of the AR curve is 40 decibels per decade. The value of the time constant is determined by drawing straight lines (called AR asymptotes) tangent to the AR curve at the highest and lowest measured frequencies. The intersection of the asymptotes is called the corner, or the break-point frequency (f_b). If the system is second order, the phase-shift curve should pass through 90 degrees at the break-point frequency. As shown in Fig. 6, the break point does occur at the same frequency as the 90-degree phase shift. The second-order time constant now can be computed using the formula* $T.C. = 1/2\pi f_b$. The time constant indicates the speed of response of the device: the smaller the time constant the faster the speed.

The damping factor may be determined by matching the experimental curve with theoretical curves*, or by a simple calculation. The calculation uses the formula $\gamma = AR/4\pi f_b T$, where AR is the amplitude ratio at f_b and T is the time constant. The damping factor is useful in predicting output overshoot for sudden input disturbances. For example, a damping factor greater than about 0.6 produces no overshoot, whereas 0.2 produces large overshoot.

From the frequency-response test on the flow transmitter we now have the necessary information to use this instrument in a graphical or mathematical analysis of a control system. To make a complete flow-system analysis it is necessary to have similar data on the other components in the control system, such as the controller, control valve, and transmission lines. Knowing the damping factors and time con-

*Brown and Campbell, "Principles of Servomechanisms."

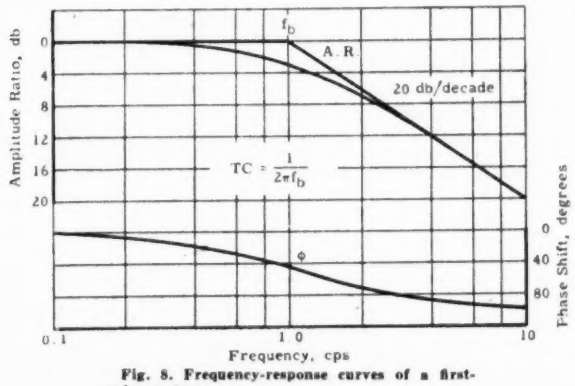

Fig. 8. Frequency-response curves of a first-order system.

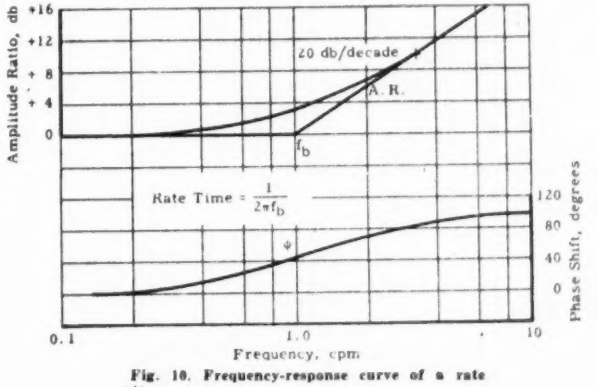

Fig. 10. Frequency-response curve of a rate unit.

stants, the control system can be simulated in computers. It is possible with the computer to experiment with control modifications with no loss of manufactured product and at a large saving in time.

First-order Systems

The first-order system and combinations of first-order systems are common in actual instruments and processes. Fig. 8 shows frequency-response curves for a typical first-order system, and Fig. 9 for a combination of two first-order systems. Each first-order system has a characteristic maximum phase shift of 90 degrees, and a slope to the *AR* asymptote of 20 decibels per decade. When two first-order systems are combined in one unit (Fig. 9) the slope of the *AR* curve is 20 db/decade until the break point of the faster time-constant is reached. At this point the two 20 db/decade slopes add to produce a 40 db/decade slope. The time constant of a single-order system can be calculated in the same manner as that for a second-order system. First the break-point frequency must be determined by drawing the amplitude asymptotes, and then the time constant calculated by formula $T.C. = 1/2\pi f_b$. The phase-shift curve for a simple first-order system should pass through 45 degrees at the break-point frequency.

When the two first-order systems are added they produce two break-point frequencies (f_{b1}, f_{b2}) as shown in Fig. 9. The first break point has an associated phase shift of approximately 45 degrees, and the second break point has an associated phase shift of approximately 135 degrees, which is the 90 degrees developed by the slower time-constant plus the 45 degrees of the faster time-constant. It is possible that an instrument may have several first-order systems with time constants spread over a wide frequency range. If these time constants are close together they will interact, and the *AR* slopes and break points with their phase-shift check points will not be defined clearly. In this case the engineer should use the curves in a graphical analysis, and not try the mathematical approach.

All the systems described introduce phase lag and attenuation. It is possible to have lead systems, or, as they are commonly called, rate or derivative units. Lead systems are the reciprocal of a first-order lag in which the *AR* curve rises at 20 decibels per decade, and the phase lag increases to a maximum of 90 degrees lead. Again the asymptotes to the *AR* curve can be drawn and the rate time calculated using the formula $T.C. = 1/2\pi f_b$. The phase lead should be 45 degrees at f_b. Fig. 10 shows the frequency response of a lead system.

Description of Automatic Controllers by Frequency Response

The pneumatic controller contains adjustable control functions: gain, reset, and rate. The gain affects the entire frequency-response curve by shifting it up or down on the *AR* axis. The reset shapes the low-frequency end of the curve, and the rate action shapes the high-frequency end, as shown in Fig. 11. From the frequency response of a pneumatic controller having all the three functions, the reset and rate break-points can be evaluated. These break points are used to calculate the reset time and rate time.

The test setup for a controller would be similar to that used for the flow transmitter. At the low frequencies there is high gain due to reset action, the *AR* drops off at 20 decibels per decade, and the phase shift rises from 90 degrees lag to zero. At the middle frequencies the *AR* curve flattens out and the phase shift approaches zero. The reset time now can be calculated by drawing the asymptotes to the 20 decibels-per-decade slope and to the horizontal part of the *AR* curve. The intersection of these two lines is called the reset break-point frequency. The reset time can be calculated by use of the formula ($Reset\ Time = 1/2\pi f_b$), which is shown as 0.16 min. or 6.25 repeats per minute in Fig. 11. As the reset rate increases, the reset break-point shifts to a higher frequency, which increases gain at low frequencies.

As the frequency is increased still further the *AR* increases and starts to lead the input due to the rate action. The rate time can be calculated in a manner similar to the reset time calculation, and is shown in Fig. 11 as 0.055 min. The rate break-point shifts to a lower frequency as rate time is increased. This produces high gain at the higher frequencies. The gain or proportional band of the controller can be determined by the level or the flat part of the *AR* curve, which is a gain of 1.0 in this controller. In some controllers the high-frequency gain due to rate action is purposely limited because noise which is normally present at higher frequencies would be amplified. The controller frequency test is completed by increasing the frequency until the ultimate is reached. At this point the mechanical time constants of the controller, such as the flapper-nozzle, pilot valve, and linkages are introduced. The amplitude-ratio curve drops rapidly, and the associated phase lag develops. At this frequency and beyond, the instrument is no longer of value as a controller.

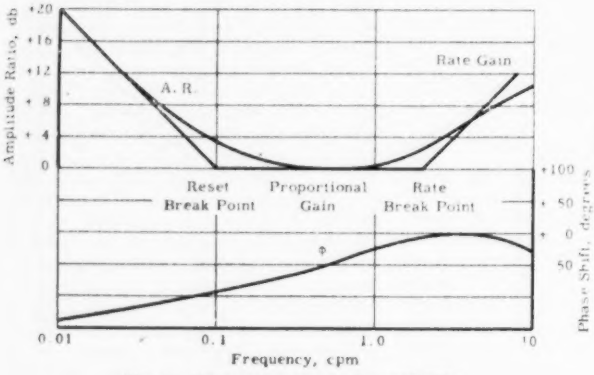

Fig. 11. Frequency-response of a controller.

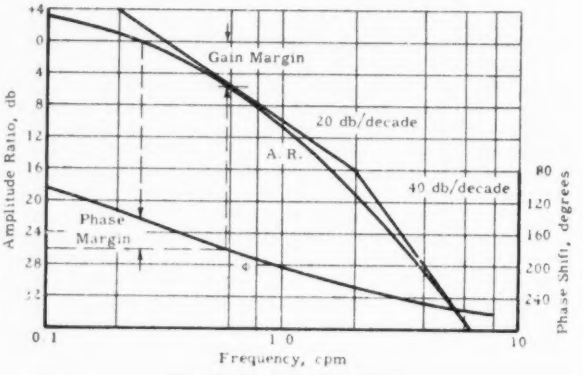

Fig. 12. Phase and gain margin.

Control System Stability

Complete control system studies can be made using the component frequency-response curves. To analyze the entire system, the frequency-response data of the components are plotted on a common frequency axis. The amplitude ratios are then multiplied, and the phase shifts are added linearly. With the amplitude ratios plotted in decibels ($20\ log_{10}\ AR$), the amplitudes are automatically multiplied when the ratios are added. The final result is a frequency-response curve for the process and control system combined. An unstable condition will exist when the control loop gain is 1.0 and the phase shift is 180 degrees. (This condition is represented by a point on the Nyquist plot called the minus one point.) One can quickly check the gain value at the 180-degree phase lag to determine if the system will be stable.

A system normally is operated with a phase or gain margin. The phase margin is the amount the phase lag is less than 180 degrees at a gain of 1.0, the gain margin is the amount the gain is below 1.0 at 180-degree phase shift. Phase margin and gain margin are not independent and often the simplest way in which the phase margin can be improved is to lower the gain of the controller. A good practical phase margin is 30 degrees.

Fig. 12 shows the frequency response of a complete system, and shows the phase and gain margin. In some practical cases the process may change enough during a normal day's operation to require a phase margin larger than 30 degrees. These environmental conditions must be evaluated for each process and control system. From system studies the control stability and speed of response can be predicted. The most desirable features of a control system are sensitive measurement, fast control action, and system stability. Of there three features, stability is most important in process control problems. If the system is unstable it is because one of the components is introducing too much gain or phase shift. There may be practical limitations as to which component can be changed to improve stability. These limitations normally force the control engineer to modify his circuit or change control components. If the latter, it is necessary to pick the correct replacement. To do this the frequency-response curves of several instruments are necessary.

Stability can be obtained either by lowering the gain or by decreasing the phase lag. The most desirable improvement would be to decrease the phase shift by use of rate action. Unfortunately this is a difficult improvement to add to a control loop. Therefore, stability is normally obtained by lowering the gain, which sacrifices some speed of response.

Conclusions

Dynamic analyses are being made on processes and process control equipment. Although testing methods and design techniques are being improved, they are still time consuming and require expensive test equipment. It is hoped that faster and simpler methods of frequency testing will be developed. One possibility is the use of computers to run Fourier analyses on transient responses. With the present theories and technology the frequency-response test is essential for process control-system analysis.

Acknowledgement

The author wishes to thank Messrs. D. J. Pompeo, P. R. Hoyt and A. Bremer for their suggestions and help.

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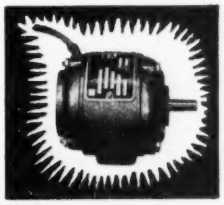

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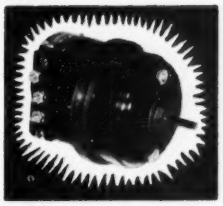

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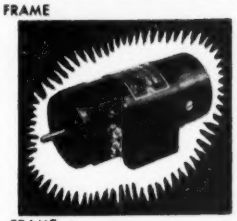

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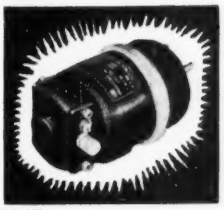

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For further information circle 130 on inquiry card.

Electronic Control

continued from page 730

of the controller. Term (2) represents the dynamic characteristic of the phase-sensitive rectifier. Its response is approximated by a single time-lag having a time constant T_P. This term has no appreciable effect on the controller response at frequencies normally encountered in process control work.

Term (3) represents the response of the rate amplifier. The rate time is varied by changing the time constant T_D.

Similarly, term (4) represents the response of the reset amplifier. The reset rate is adjusted by varying time constant T_R.

By substitution of various values of frequency (ω) into the transfer-function expression, it is possible to plot the amplitude and phase response of the controller in terms of frequency (ω). Generalized plots of these curves are shown in Fig. 12. It is interesting to examine the effect of the various controller adjustments on these curves.

Adjustment of the proportional-band control merely displaces the amplitude curve vertically; its shape is not altered in any way. A decrease in proportional band moves the curve upward. The phase curve is not altered.

The reset-rate adjustment moves portion (A) of the amplitude curve to the right or left. Slower reset rates move this part of the curve to the left.

On the phase curve, points (D) and (E) move to the right or left in accordance with the shifts of the amplitude curve.

The advantages of electronic control are (1) elimination of time lag in transmission of information, (2) stability of controller characteristics; there are no needle valves or orifices to become clogged, (3) reduced installation cost; electrical conduit is cheaper than copper tubing lines, (4) simplied maintenance with plug-in construction, (5) infinite controller sensitivity without friction or hysteresis, (6) high speed of response, and (7) elimination of freezing problems.

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90 pages
Cloth, 5 x 8 inches. Profusely illustrated with circuit diagrams, schematic diagrams and photographs.

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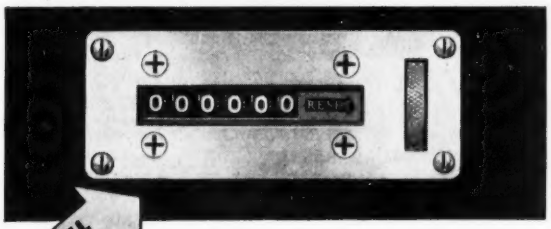

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ATLAS

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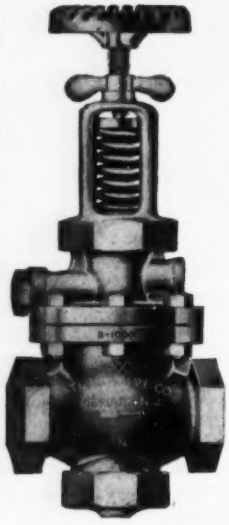
Type "B"



In our 52-page bulletin 1-A ten pages are devoted to ATLAS Type "B" Reducing Valves. Fig. 112, shown here, is a bronze body reducing valve for 300 pounds steam service. For reduced working pressures from 10 lb. to within 20 pounds of the initial pressure in one stage.

Fig. 114 has an iron body. For initial working pressures from 20 to 250 lb. saturated steam. Reduced: same as Fig. 112.

Fig. 112 (LP) is similar in most ways to Fig. 112 but handles reduced working pressures of ½ to 15 lb.

Fig. 114 (LP) has an iron body. Similar to Fig. 114 but handles reduced working pressures of ½ to 15 lb.

Then come the steel bodies—right from Series 15 to Series 90, for all the way up to 900 lb. pressure with 900° F temperature. Some of them handle reduced working pressures from 10 lb. to within 30 pounds of the initial pressure in one stage and the others handle reduced working pressures from ½ lb. to 15 lb.

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The pilot valves are solid Stellite. The pilot valve seats are Stellite faced. In the steel body valves the main valve seat is solid Stellite. Stellite assures long life because it is practically immune to severe abrasion and corrosion.

Type "B" valves are recommended for reducing the pressure of steam where the service demands a tight seating valve and a uniform reduced pressure. Simple to maintain. Main valve and pilot valve are easily removed for cleaning. Entire pilot valve can be lifted out without difficulty.

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Control Valves
Oil Control Cocks

For further information circle 134 on inquiry card.

SOAKING PIT INSTRUMENTATION

Continued from page 726

by Combustion Department personnel are located behind the panel board. In this manner the inexperienced operator is prevented from making ratio adjustments, pressure settings, etc. This feature has simplified the control panel and has worked out satisfactorily.

Instruments or controls common to all pits in a single battery are located on a battery master panel. These include the fuel-gas pressure recorder, combustion-air pressure recorder, metallic-recuperator air-temperature recorder and overtemperature controller, final air-temperature recorder, and flue-gas temperature recorder.

The metallic recuperator must be protected from overheating due to excessive flue-gas temperature or operation at low air-flow rates. This is accomplished by use of a bleeder on the hot side of the recuperator so as to raise the

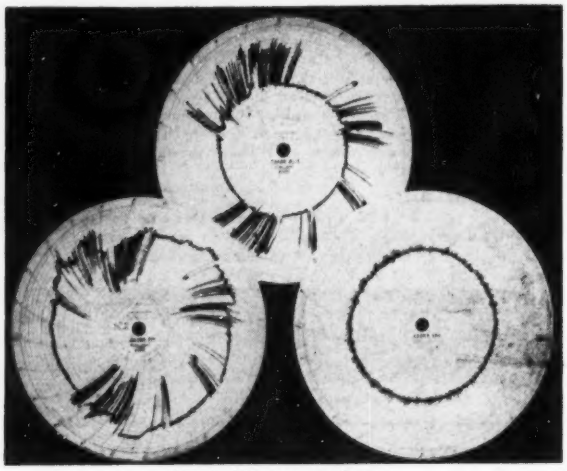

Fig. 7. Pit pressure charts.

air volume through the tubes in event of high air temperature. This cools the tubes sufficiently to prevent damage.

The combustion-air pressure controller is operated to maintain a constant air pressure against the air-flow control valves. This is accomplished by a control operator which positions the jet in the throat of the jet pump (Fig. 6). Any variation in air flow creates a fluctuation in air pressure. The deviation from normal is measured and the jet needle repositioned to reestablish the desired air pressure. The function of the combustion-air temperature recorder-controller was discussed previously.

The flue-gas temperature recorder records metallic air temperature and flue-gas temperatures before and after the metallic recuperator. This and the fuel-gas pressure recorder are purely for operating information.

Conclusion

The following statements were made in 1926 at a meeting of a group of Combustion Engineers of the Bethlehem Steel Company:

"In general there are a few conditions that must be met to obtain good results in combustion. . . . The correct proportion of gas and air and an intimate mixture of these might be considered the most important. It is quite possible to have a condition of excess air in a furnace and at the same time an appearance of excess gas, and unburned gas discharging out the back, all due to the wrong proportion to start, concealed by poor mixing, resulting in a long flame, low temperature, stratification in the furnace and waste of gas.

"With a constant gas pressure maintained up to the control valve, an air supply that does not change of itself, and good mixing burners, it is possible to maintain good results

Continued on page 754

Book Reviews

ELECTRIC CONTROL SYSTEMS
Richard W. Jones

John Wiley & Sons, Inc., 440 4th Ave., New York 16, N. Y., 512 pages, 1953, $7.75

This third edition is directed toward senior students who have had courses in a-c. and d-c. machinery, ordinary differential equations, and basic electronics. It uses both analyses and graphical methods to develop basic ideas of motor control. D-c. and a-c. motor characteristics are presented first, followed by methods of motor control by contact-making devices, gas tubes, electronic switches, and power amplifiers. Control-circuit fundamentals are extended to acceleration, speed, and braking problems. Feedback control systems and motor protection are the final two chapters.

ELECTRONIC MEASUREMENTS
F. E. Terman and J. M. Pettit

McGraw-Hill Co., Inc. 330 W. 42nd St., New York 36, N. Y., 1952, 708 pages, $10.00

Designed as a college text and reference book for the practicing engineer, this book covers measurements in radio engineering—voltage and current, power, transmission lines, frequency, waveforms, time interval, etc. Chapters are devoted to characteristics of tubes, amplifier measurements, receiver measurements, antennas, and laboratory oscillators. The final chapters are devoted to reactance and resistance standards, and attenuators and signal generators.

THE SCIENCE OF COLOR
Committee on Colorimetry of the Optical Society of America

Thomas Y. Crowell Co., 432 4th Ave., New York 16, N. Y., 1953, 386 pages, $7.00

This definitive account of the science of color begins with the story of the use of color by prehistoric man. Succeeding chapters carry the reader into the philosophy of color, the physiology of color vision, the psychology of color, the physical principles of color and, finally, to psychophysics that has made possible the measurement and control of color. Methods of colorimetry, colorimeters, and color standards are presented. Includes 25 full-color plates, a 22-page bibliography, and a 23-page glossary-index of definitions and terms.

ELECTRONIC CIRCUITRY FOR INSTRUMENTS AND EQUIPMENT
Milton H. Aronson

Instruments Publishing Co., 921 Ridge Ave., Pittsburgh 12, Pa., 1953. viii + 310 pages, $4.00

In nonmathematical style suitable for technicians and engineers, the author first presents electrical fundamentals —resistance, capacitance, inductance, impedance, resonance, and signal shaping. Next, vacuum-tube and gas-tube fundamentals are presented, followed by amplification, rectification, and oscillation circuits, including electrometer tubes, cathode followers, clippers, limiters, clampers, peakers, modulators, demodulators, etc. Each unit is covered thoroughly. For example, the chapter on oscillator circuits presents over twenty basic oscillator circuits. Especially noteworthy is the chapter on solid-state amplifiers, which presents the operation of magnetic, dielectric, and transistor amplifiers. The book contains more than 450 multiple-choice home-study type question items (30 to 40 per chapter), so that it may be considered as a text and home-study course for anybody who wishes either (1) to learn electronic circuitry for instrument, communication, TV, or military electronics, or (2) to keep abreast of developments (plasmatrons, ignitrons, transistors, etc).

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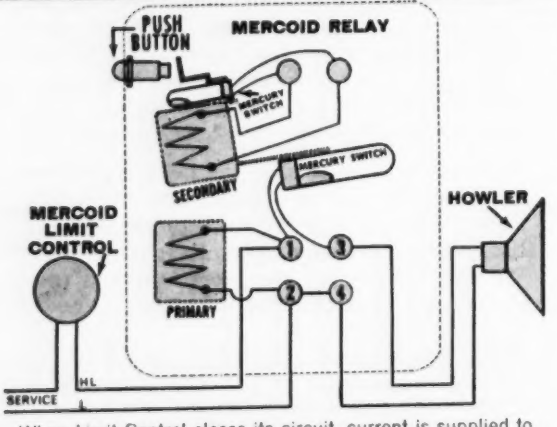

When Limit Control closes its circuit, current is supplied to primary coil of Mercoid Relay and through the normally closed mercury switch to the "Howler" (alarm). To stop "Howler," operator pushes in "push button" which manually raises relay secondary and breaks circuit to "Howler." Secondary is held up by magnetic repulsion until condition is corrected. When limit control opens the primary circuit of relay, secondary coil drops to normal position and relay is automatically ready for another operation.

WRITE FOR BULLETIN CA-8R

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For further information circle **137** on inquiry card.

by hand control. With conditions other than this it is not possible.

"Another important condition having more to do with heating than the quality of combustion, though affecting both, is the draft and damper control. As much of the furnace as practicable should be kept under atmospheric pressure to prevent infiltration of cold air.

"Both the control of the gas and air mixture, and that of the stack damper, is being done automatically today to a greater or less extent . . . combustion control is not yet sufficiently developed. . . . It may be necessary to wait until such control can be made to function from the quality of the waste gases, which after all, seems the only logical solution."

It would appear from these statements that the fundamentals are still the same, but that the equipment available to the industry is vastly improved today. We in the steel industry should be grateful to the instrument and control manufacturers for their cooperation in solving the problems connected with combustion and making the modern soaking pit as well as other reheating furnaces relatively trouble free and highly efficient.

BATH TEMPERATURE PYROMETRY

Continued from page 723

One standard checking unit for many field units. It is not necessary to return to the Instrument Shop for standardizing purposes.

Short immersion time. About five to six seconds are needed to reach maximum temperature. Shorter time in the furnace means longer equipment life.

Readings can be taken with only five to ten minutes delay. No waiting for a "cold junction" to cool before using again.

No around-the-clock maintenance. No tips to replace or cement to dry before re-using.

Less immersion units needed. One spare unit can be used for a large bank of furnaces.

Unfavorable

The following unfavorable comments have been expressed by users of the "Rayotube" system:

Heavy and bulky and hard to handle, requiring the aid of a helper to remove from furnace.

Fogging of radiation unit, causing low readings and constant checking of the "Rayotube."

Closing of the end aperture, causing low readings to the point where the unit will not standardize with check unit

Air must be clean and dry, causing a serious problem in some plants.

Costly to install. The complete system is too costly for the small plant to use.

The figures of the cost per reading (about 75 cents) were slightly less than for the thermocouple, although it has been reported that this figure is high. One plant has figured that if no electrical or mechanical failures mar the record, readings should not cost over 10 to 12 cents per reading.

"Who operates the immersion equipment?" was an interesting question. The answers varied from the observer in the Metallurgical Department to the second helper on the furnaces. This seems to be a matter of individual plant choice.

Summary

The immersion method of bath-temperature measurement is becoming routine practice in progressive steel companies. The trend today is favoring the thermocouple-type immersion unit for production use. The two outstanding reasons for this are: (1) Production men and operating personnel have been more receptive to the thermocouple system, and (2) the "Rayotube" type is more costly to install, and in most cases, costly to maintain, considering down-time and out-of-order time.

Regardless of which type is used, the bath-temperature pyrometer is a working tool of the melter, to assist him in the art of steelmaking.

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NEW SAFETY FEATURES. Two-filament lamps avoid light source failure. Safety relay stays open until amplifier warms up—opens automatically when a tube filament fails.

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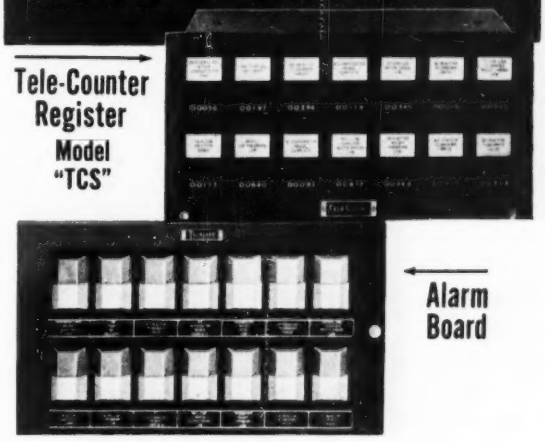

It is often very important to know the frequency at which any point of the Annunciator System is off-normal. To supply this information the new MODEL "TC" TELE-COUNTER keeps continuous count of every off-normal signal as indicated by the Tel-Alarm Annunciator.

Any number of individual alarm points of the alarm system may be selected for totalizing or the entire unit may be equipped with the TELE-COUNT device. Repeater window markings on the totalizer unit readily identifies each associated signal station on the main annunciator board.

The MODEL "TCS", in addition to the individual totalizers, is designed with signal sequence selector, whereby the initial off-normal signal at the annunciator is immediately indicated by an engraved, illuminated window placed directly above the corresponding counter totalizer. This is essential in determining which piece of equipment or step in the process failed first, such as in a series of pumps or continuous process functions.

Both types of TELE-COUNTERS can be adapted to any existing Tel-Alarm Annunciator Systems by simple connections in the field. They are available in any multiples to correspond to the equivalent number of stations on the original annunciator panel or any selected portion of it.

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For complete information and literature write for Bulletin "TCS":

Tigerman Engineering COMPANY

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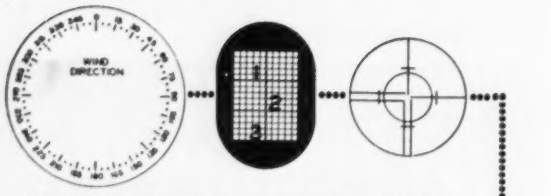

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For further information circle 143 on inquiry card.

PROCESS CONTROL

continued from page 726

to a large value. Similarly, a sustained change in supply or demand will be followed by sustained "hunting."

In setting up a proportional controller a compromise must be made between narrowing the proportional band to decrease offset and keeping it wide enough to prevent instability.

Unless a narrow band can be used, proportional control action is inadequate for any process in which large load changes are likely to occur and in which the resulting offset cannot be tolerated.

Since the proportional controller is the simplest continuous controller (and therefore the cheapest in initial cost, adjustment at starting up the plant, and subsequent maintenance) we shall examine the process characteristics which permit a narrow band to be used without instability.

Distinction Between "Action" and "Control"

Confusion can easily arise between the meaning of "action" and "control" and between the coefficients defining the action and the control factors. In addition to K_1 and μ, the symbols K_0 and γ, and K_2 and ρ will appear later as the corresponding coefficients and factors for integral and derivative controllers respectively.

Control characteristics usually are defined by use of μ, S, and R, where S is μ/γ, and R is ρ/μ. The terms ρ, γ and K_1, K_2 and K_0 generally enter only into the *explanation* of control theory and controller operation.

The controller *action* defines the response of the controller itself; *control* refers to the whole control system, and depends on the regulating unit and plant characteristics.

Hence, if the pneumatic controller has proportional action, the pressure output from the controller will be proportional to the deviation. If the control system is said to be operating under proportional control, then the potential correction applied by the regulating unit is proportional to the deviation, *i.e.*, the potential change in controlled condition is proportional to the deviation.

The distinction is necessary because the regulating unit has not necessarily a linear characteristic. If it has not, although controller action is proportional, the regulating unit may give a correction perhaps proportional to the square of the change in pressure applied to it. Clearly, the potential correction will no longer be proportional to the deviation, but to its square.

For present purposes it is sufficient to assume linearity in the system, including the regulating unit and plant.

Criteria of Good Control

The first essential in studying the relationship between plant and controller characteristics is to establish the criteria for good control.

A control system is required to achieve the following conditions:

(i) Small deviation from desired value following a disturbance, *i.e.*, to give a high "deviation reduction factor."

(ii) Quick return to control point* after a disturbance causing oscillation, *i.e.*, to give a satisfactory value (*e.g.*, *e*:1) of the "subsidence ratio" at short oscillating period.

(iii) Small deviation of controlled condition from the desired value when conditions are steady, in spite of changes which may have occurred in supply or demand in the plant, *i.e.*, to keep "offset" at a minimum.

The relative importance of (i), (ii), and (iii) varies from process to process. Plant requirements in any given application will decide which of these three conditions is the most important.

Recovery after a Disturbance

The curves in Fig. 5-3 show three representative types of record given by a proportional control system following

*B.S.I. Definition No. 2201, "Control point: the value of the controlled condition which the automatic controller actually maintains under steady-state conditions."

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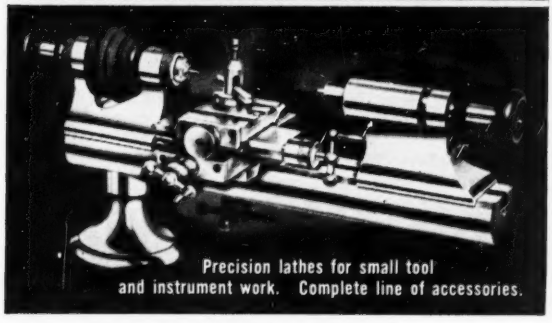

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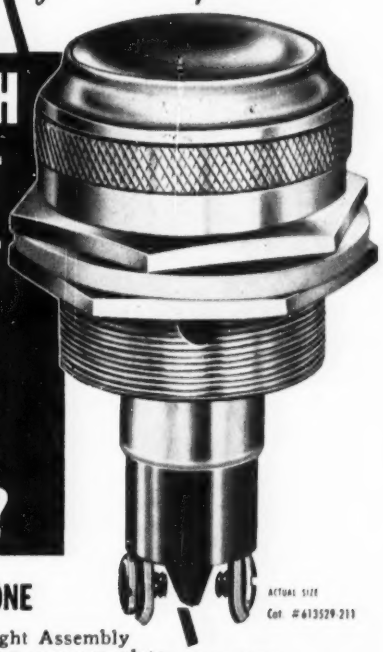

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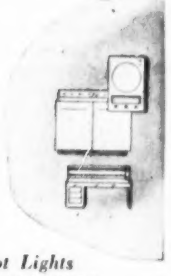

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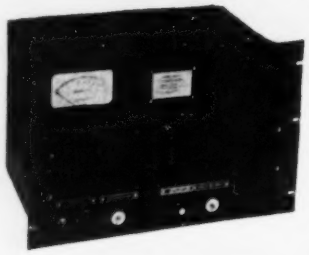

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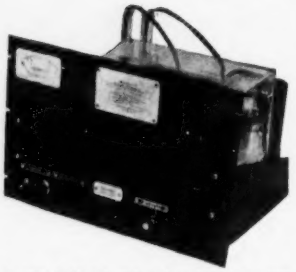

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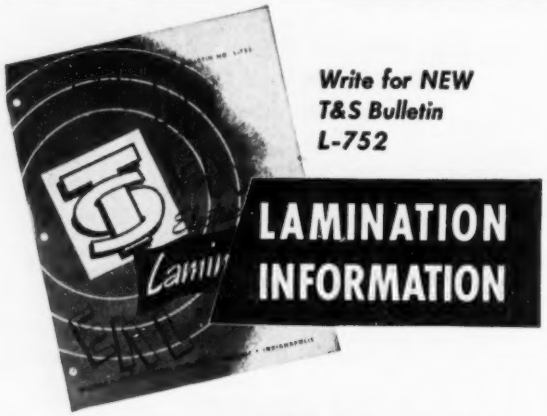

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a sudden change in demand. They differ from the type of record in Fig. 5-1 in exhibiting "overshoot" and subsequent oscillation, which is damped out at a rate depending on the width of the proportional band.

The difference is due to the time lags in the system. Without time lags "overshoot" would not occur because immediate corrective action would be taken by the controller. Oscillations could neither be set up nor maintained. In Fig. 5-1 the plant conditions are changing so slowly that the time lags are negligible and the control can therefore succeed in making corrections to the setting of the regulating unit sufficiently rapidly to follow the changing demand at each instant.

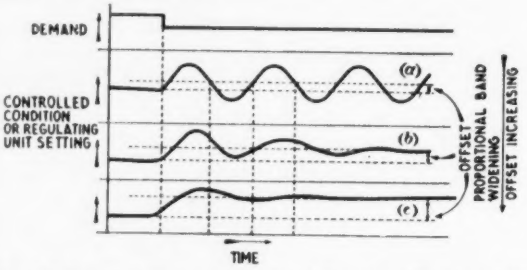


Fig. 5-3. Responses of a proportional-control system following a sudden change in demand for various proportional bands.

It can be seen from Fig. 5-3 that, as the proportional band is widened, the oscillations set up in the control loop are damped out more quickly. At the same time offset increases. Also, widening the proportional band increases the period of the oscillations.

Deviation Reduction Factor

In any stable system the amplitude of oscillation of the value of the controlled condition is as shown by curves (*a*), (*b*) or (*c*) in Fig. 5-3. The amplitude is never greater than at the first peak following a disturbance; *i.e.*, the initial overshoot is the greatest (say θ_m). The value of θ_m will depend on the plant characteristics as well as on those of the controller. Therefore in order to provide a measure of the performance of the controller, the maximum deviation (θ_m) with control can be compared to the deviation that would have occurred in the absence of control (say θ_p). It will be remembered that the value of θ_p depends on the inherent regulation of the plant and that θ_p is known as the potential deviation.

In Fig. 5-4 the deviation of the controlled condition, for a given process following a distrubance in demand, is plotted against time for (*a*) no control, and (*b*) proportional control. The deviation which would have occurred in the absence of control (θ_p) is reduced to a maximum deviation of θ_m by the controller. The ratio θ_p/θ_m therefore gives a good measure of the efficiency of control in keeping overshoot to a minimum. In the absence of a standard term for this ratio, it may be called the "deviation reduction factor."

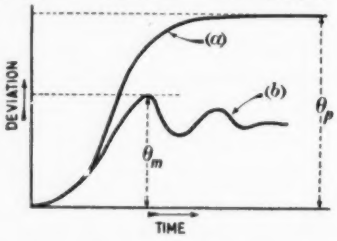
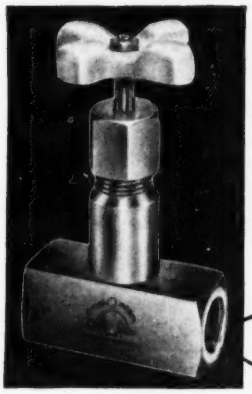


Fig. 5-4. Deviation of controlled condition following a disturbance in demand for (a) no control, and (b) proportional control.

It can be shown that the deviation reduction factor is in general proportional to the value of the proportion control factor (μ) and hence, to minimize overshoot, a high value of μ is desirable.

Subsidence Ratio

Of the three types of recovery shown in Fig. 5-3, that of curve (*b*) offers the best compromise between quick damping out of the oscillations and magnitude of offset. It is



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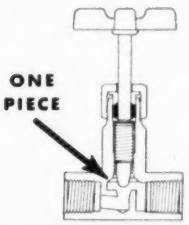

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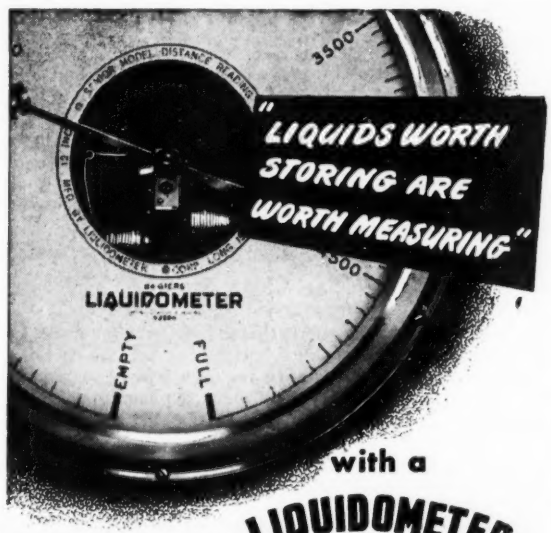

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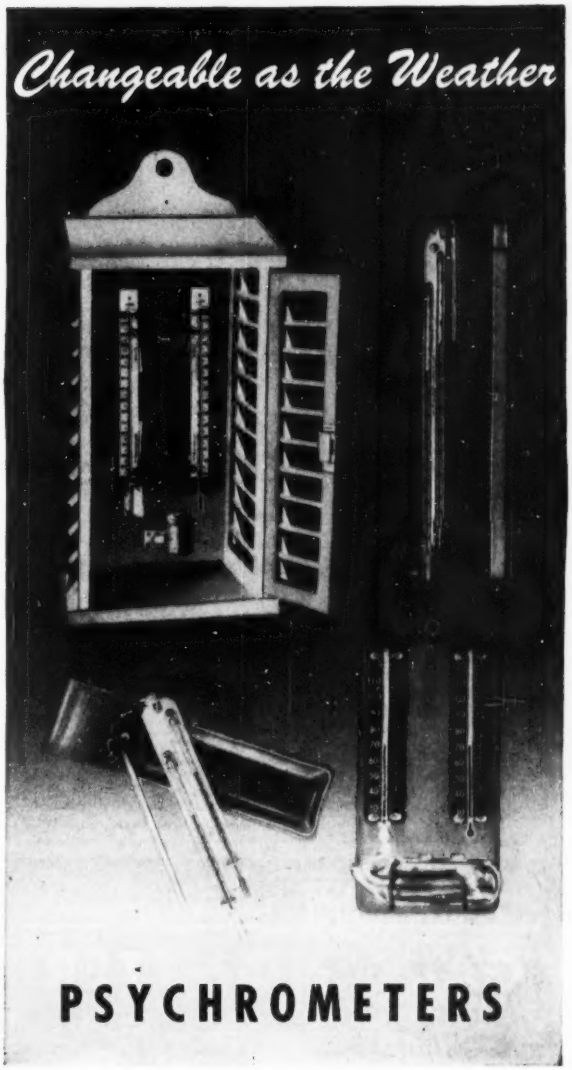

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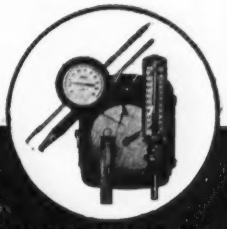

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a matter of common experience that damping increases as the proportional band is widened (so that steady running at the control point is attained more quickly) but that the offset is increased. It will also be noticed that the period of the oscillation increases as the proportional band widens.

It is convenient to have a measure of the rate of damping of the oscillations and (again in absence of a standard term) it can be called the "subsidence ratio," defined as: "the ratio of the peak of one oscillation to that of the succeeding peak in the same direction," *i.e.* x/y in Fig. 5-5.

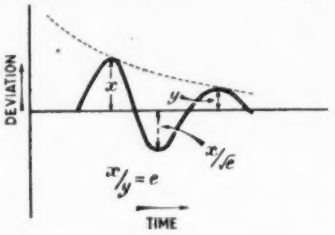

Fig. 5-5. Subsidence ratio of a damped wave form.

The best value of the subsidence ratio must be selected for each process. It may vary from 2 to 4 or more, according to the application. For the purpose of this discussion a value of e: 1 is taken as a working average value, which will be quite suitable for many installations, where e is 2.7183, the base of natural logarithms.

It should be noted that the subsidence ratio only determines the *number* of oscillations which will occur before steady conditions are achieved. Therefore, in order to achieve rapid return to steady running, the period of the oscillations must be small.

We must therefore examine the conditions which determine the period of the oscillations set up in a control system by a disturbance in the process. The simplest approach is to assume in the first place that a step disturbance occurs in the supply, *i.e.*, that a sudden, sustained disturbance enters the control loop through the regulating unit. Further, let us assume that the disturbance sets up "hunting" in the control system and therefore that the recorder operating from the detecting element commences to produce that most familiar of all records, shown in Fig. 5-3, curve (*a*), which has a sine wave form. Just as we can adjust the controller on the plant to give stable control by first obtaining this type of record and then readjusting to obtain the damped wave form (Fig. 5-5) on the recorder, so we can investigate theoretically the conditions which give the sine wave oscillation of constant amplitude and then find the adjustments necessary in these conditions to give damped oscillations with subsidence ratio e:1.

To be continued

Michigan Conference

continued from page 666

different types of education. Questions that remained unanswered included:

(1) How large is the demand for each *type* of instrument man—design men, development men, application men—by industry?

(2) Can or should colleges train one or all types?

(3) Should college training in instrumentation be required of all technical students, or of only certain engineering departments?

(4) Are college instructors and professors up-to-date on instruments and instrumentation?

(5) How does one become "instrument minded"?

We hope that these specific questions will be treated in future conferences on the subject. Until that time we humbly suggest to the educators that a simple and economical way to keep abreast of the rapidly changing field of instrumentation is to read *Instruments* every month, and thus: (1) learn about the new instruments that become commercially available month by month; (2) learn about new principles and applications described in the technical articles; (3) note the latest commercial literature and send for items of interest; . . . and so on. Even their students may find this an easy way to learn about the instrument portion of "instrumentation." —MHA

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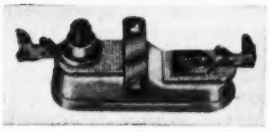

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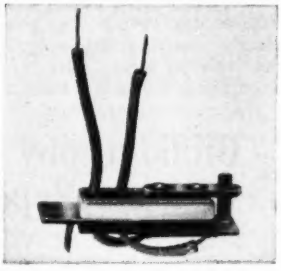

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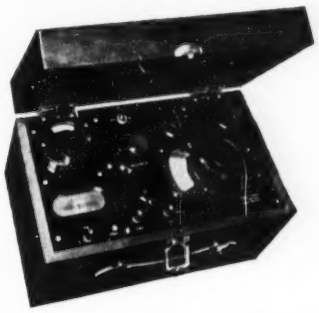

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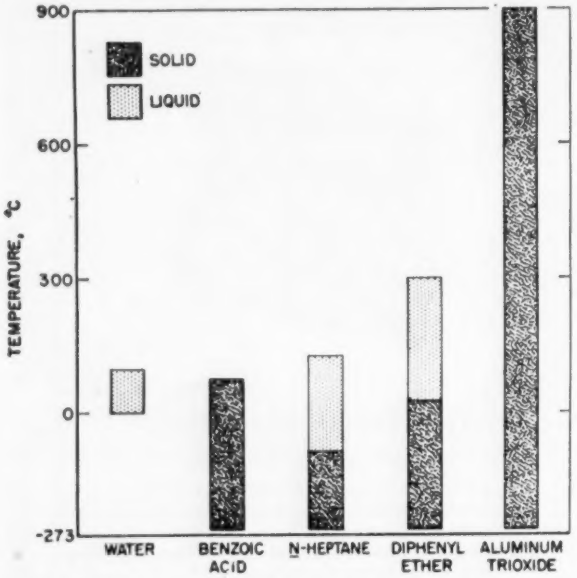
The method chosen to locate the leak consisted of pumping various substances through the pipe and using detection apparatus in boats on the river. After several materials were tested, a brine solution was tried, and a conductivity measurement of the river water was used as an indicator. The detector consisted of a test cell that could be immersed in the water and a General Radio "Type 650-A" impedance bridge to measure the cell resistance. Some twelve tons of salt were used in the test. As the boat moved along, the galvanometer was kept at zero by changing the setting of the main resistance dial to balance the progressive change in water resistance. The leak was located in a short time, about 650 feet off shore.

Heat-capacity Standards

WASHINGTON, D. C.—With the extension of heat measurements toward the extremes of the temperature scale, the National Bureau of Standards is developing new standards of heat capacity for use at temperatures where water, the present standard substance, cannot conveniently be employed. Special samples of three materials—benzoic

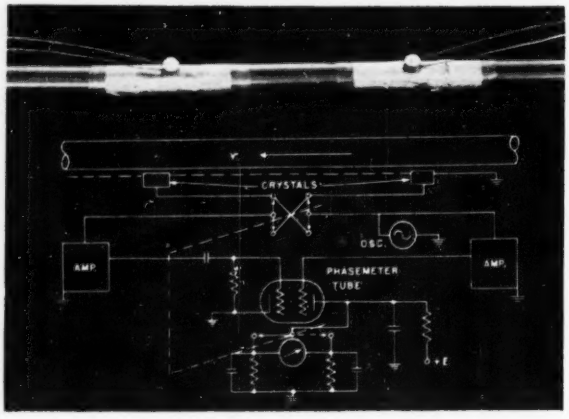


acid, *n*-heptane, and aluminum oxide—have already been prepared and their heat capacities determined over most of the useful temperature range, and a limited number of these samples are being made available to laboratories equipped to make precise measurements of heat capacity.

The illustration compares the useful range of water as a heat-capacity standard with the useful ranges of the new heat-capacity standards. Further information regarding the heat-capacity standards may be obtained from Dr. D. C. Ginnings, National Bureau of Standards, Washington 25, D. C.

Electronic Flowmeter

WASHINGTON, D. C.—A new type of electronic flowmeter, capable of measuring the air currents in a still room or the rapid flow of fluids in pipes, has recently been developed at the National Bureau of Standards by Henry P. Kalmus. It utilizes the change in velocity of radio waves as a measure of fluid flow. It has fast response and does not obstruct the fluid currents to make the measurement. A 100-kc. wave is transmitted over a fixed distance through the flowing fluid, and the phase of the received wave is com-



pared with that of the transmitted wave. The sound energy is imparted to and taken from the fluid through the walls of the containing vessel. A mechanical switching system operating at a 10-cycle-per-second rate (or an electronic switch operating at 1000 cps.) is employed.

Sound waves are transmitted into the fluid through the walls of the container and are received by magnetostrictive or piezoelectric exciters, such as barium titanate crystals. The transmitter and receiver of the new flowmeter are exchanged periodically by the switching system. The sound energy is amplified and passed on to a multigrid phasemeter tube. The output of the phasemeter is applied to an electronic voltmeter (which can be calibrated directly in terms of velocity) through a switch connected to the same drive that switches the crystals. One phase shift is a function of wave velocity *plus* fluid flow velocity; the other is a function of wave velocity *minus* fluid velocity. Thus the difference between phase shifts is a measure of fluid velocity.

Bibliography of Technical Reports

WASHINGTON, D. C.—Valuable technical developments in the field of industrial measuring, testing, and control equipment are available from the Office of Technical Services of the U. S. Department of Commerce, Washington 25, D. C.

Each month, the Office of Technical Services releases through its publication, the *Bibliography of Technical Reports*, reports on scientific and financial support which are cleared of secrecy restrictions. Many valuable technological developments for the measurement and control equipment industry are described in the reports.

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Manufacturers' New Literature

In this department we report new literature, pertaining to instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on Page 785.

Requests for literature FROM ABROAD should be made on company letterhead and mailed DIRECTLY to the manufacturers.

Temperature

Temperature Conversion Chart. New chart for converting temperatures to either Fahr. or Cent. is based on data compiled by Dr. A. Sauver, and contains figures for from minus 70 to plus 650 deg. Reverse side describes maker's line of thermostats.—Stevens Mfg. Co., Mansfield, Ohio.

Circle **401** on inquiry card.

Indicating Millivoltmeter Controllers. New 4-page specification Sheet 116 describes and illustrates "Pyr-O-Vane, Pulse Pyr-O-Vane, and Protect-O-Vane" automatic controllers which provide regulation of temperature. Includes construction and engineering details.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **402** on inquiry card.

Temperature Control. New 4-page condensed Catalog G-18 describes and illustrates maker's one, two, and three switch temperature controls. Includes functions and instrument selection chart.—Burling Instrument Co., 5 Vose Ave., South Orange, N. J.

Circle **403** on inquiry card.

Thermal Controls. New 4-page Bulletin 8-7.5 illustrates and describes maker's line of field-tested thermal controls, thermostats, etc. for product manufacturers needing electric heat control.—George Ulanet Co., 413 Market St., Newark 5, N. J.

Circle **404** on inquiry card.

Surface Pyrometer. New 6-page Catalog 168 describes maker's "Pyro" surface pyrometer for surface and sub-surface temperature readings. Includes list of applications.—The Pyrometer Instrument Co., Inc., Bergenfield, N. J.

Circle **405** on inquiry card.

Pneumatic Temperature Control. New 4-page Bulletin 2-6-1 describes and illustrates maker's "Model 107614" pneumatic temperature control which operates automatically at preselected values and is adaptable to all aircraft systems. Includes principle, operation, performance, and applications.—The Garrett Corp., 9851 Sepulveda Blvd., Los Angeles 45, Calif.

Circle **406** on inquiry card.

Temperature Control. New release describes maker's new temperature control that uses transistors and magnetic amplifiers to control within 0.5 deg. to 1000 deg. F.—Federal Telephone and Radio Corp., 100 Kingsland Rd., Clifton, N. J.

Circle **407** on inquiry card.

Acid-heating Apparatus. New 4-page brochure illustrates and describes maker's "Clepco Glorod" for acid heating and alkaline bath heaters. Includes features, dimensions, and control selection.—Cleveland Process Co., 7016 Euclid Ave., Cleveland 3, Ohio.

Circle **408** on inquiry card.

Pressure, Vacuum

Manometers, Flow Meters. New 4-page illustrated brochure describes maker's "Red Line" manometers, absolute pressure and U-tube manometers, indicating flow meters, orifice flanges and plates. Includes features.—Trimount Instrument Co., 3119 W. Lake St., Chicago 12, Ill.

Circle **409** on inquiry card.

Pressure Gages. New 24-page Catalog G-52 describes and illustrates maker's large line of gages, dials, accessories, etc. Includes features, construction, design, types, and applications. Also table of pressure equivalents.—Helicoid Gage Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn.

Circle **410** on inquiry card.

Pressure Transmitters. New 4-page illustrated Bulletin A-708 describes "Type P2T" pressure primary-element transmitters for use with maker's "Autronic" controlling and recording system. Includes principle and operation.—The Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.

Circle **411** on inquiry card.

Pump, Test Stand. 2-page Bulletin 500 presents features and operation of maker's air-operated power unit, for oil or water, that provides output pressure to 30,000 psi. from 100-psi. supply. New 4-page Bulletin 600 presents test stand for testing hydraulic systems for leaks.—Sprague Engineering & Sales Corp., 1144 W. 135 St., Gardena, Calif.

Circle **412** on inquiry card.

Pressure Regulators. New 8-page illustrated Bulletin 4003 describes maker's "Nullmatic" pressure regulators for general industrial-instrument use. Includes performance charts, construction features, and modifications.—Moore Products Co., Phila. 24, Pa.

Circle **413** on inquiry card.

Vacuum Gages. New 2-page bulletin illustrates and describes maker's "Model 511 Alphatron" and "Type 710" thermocouple-ionization vacuum-gage control. Includes operation and features.—National Research Corp., Equipment Div., 70 Memorial Drive, Cambridge, Mass.

Circle **414** on inquiry card.

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Leak Detector. New 2-page data sheet describes and illustrates maker's new "Type LD-01" halogen-sensitive leak detector for maintaining high vacuum systems at top operating efficiency. Includes operation, installation, and maintenance.—Consolidated Vacuum Corp., Rochester 3, N. Y.

Circle **415** on inquiry card.

Mass-spectrometer Leak Detector. New 4-page illustrated Bulletin LD-7A presents principles, applications, features, and operation of maker's "Veeco Model MS-5A" mass-spectrometer leak detector. Included are bulletins on leak-tight hermetic sealing and vacuum-system bellows valves.—Vacuum-Electronic Engineering Co., 86 Denton Ave., New Hyde Park, L. I., N. Y.

Circle **416** on inquiry card.

Flow

Indicating Flow Meters. New 22-page illustrated Bulletin 18A describes maker's "Model A-286" type-H indicating flow meter. Includes construction, mounting, diagrams, and installation.—The Meriam Instrument Co., 10920 Madison Ave., Cleveland 2, Ohio.

Circle **417** on inquiry card.

Purge Rotameters. New 2-page illustrated Bulletin 18RB presents features, applications, and specifications of maker's purge Rotameter flowmeter with back-flow check value for measuring small flows.—Schutte & Koerting Co., 26 Cornwells Heights, Bucks County, Pa.

Circle **418** on inquiry card.

Inductance Bridge Receiver. New 4-page Bulletin 1540 illustrates and describes maker's "Electronik" inductance bridge receiver for flow metering, continuous weighing, cost accounting, etc. Includes specifications and ordering information.—Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Phila. 44, Pa.

Circle **419** on inquiry card.

Flow Meter. New 2-page Instrumentation Data Sheet 10.3-6 describes system for measurement of flow of molten metals such as sodium or lead-bismuth by utilizing a GE magnetic flow meter and Brown "ElectroniK" recorder.—Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Phila. 44, Pa.

Circle **420** on inquiry card.

Motor and Centrifugal Pump. New 4-page Bulletin G 1000 illustrates and describes maker's new magnetically driven combined motor and centrifugal pump which requires no mechanical seals or stuffing boxes. Includes dimension drawings and performance curves.—Chempump Corp., 1300 E. Mermaid Lane, Phila. 18, Pa.

Circle **421** on inquiry card.

Level

Liquid-level Gages. Set of nine new data sheets covers maker's complete line of liquid-level gage valves for both tubular and flat gages, regular,

maintenance and replacement are simplified with Fairchild

plug-in potentiometers

These plug-in type ganged potentiometers are another excellent example of Fairchild's service in meeting the special requirements of customers. The problem was to provide ganged precision potentiometers that would simplify maintenance of airborne fire control equipment through quick and easy replacement. A series of packaged plug-in units like that shown was the answer.

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offset, and with union connections to gage. Includes specifications, connections available, and dimensions.—Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.

Circle 422 on inquiry card.

Liquid-level Control. New 4-page Bulletin LL4-453 describes and illustrates maker's single-thyratron electronic liquid-level control operating without radio frequency from a single capacitive probe.—Thermo Instruments Co., 1166 El Camino Real, Belmont, Calif.

Circle 423 on inquiry card.

Process Instrumentation

Process Instrumentation. New literature for maker's Bulletin Binder includes Bulletin 18 for meters and controls, G91-9 for "Armortube" cable, and specification sheet E65-1 on maker's oxygen and combustibles analyzer. —Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

Circle 424 on inquiry card.

Pneumatic Pressure Transmitter. New 4-page Bulletin 1731 illustrates and describes maker's "Model 173" pneumatic pressure transmitter (Helix Type) which provides wide angular travel for positive operation of standard motion transmitter.—Moore Products Co., Phila. 24, Pa.

Circle 425 on inquiry card.

Differential-pressure Transmitter. New 8-page Bulletin 98226 presents maker's "Transaire" differential-pressure transmitter for flow, liquid level, and specific gravity applications. Includes principle, operation, design drawings, specifications, accessories, and mounting dimensions.—Taylor Instrument Companies, Rochester 1, N. Y.

Circle 426 on inquiry card.

Ammonia Dissociator. New 4-page data sheet 4.4-5 describes Drever ammonia dissociator unit with integral Brown controller which automatically produces controlled atmosphere for heat treating.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle 427 on inquiry card.

Utility Control. New 2-page folder outlines new applications of IBM electronic time and program controls for control of utility systems. Includes description of new IBM electronic portable paging system.—International Business Machines Corp., 590 Madison Ave., New York 22, N. Y.

Circle 428 on inquiry card.

Testing, Inspection

Yarn Tension. New 12-page reprint "Some of the factors influencing yarn tension in warping" is distributed as 24th issue of "Instrument Notes."—Statham Laboratories, 12401 W. Olympic Blvd., Los Angeles 64, Calif.

Circle 429 on inquiry card.

X-ray Accessories, Supplies. New 104-page 1953 edition of "Accessories and Supplies" lists, illustrates, and describes wide range of X-ray supplies essential to industrial radiography. Includes items used in industrial medical radiography and fluoroscopy.—The Keleket X-Ray Corp., 262 W. 4 St., Covington, Ky.

Circle 430 on inquiry card.

Sonic Comparator. New brochure presents new "Model 101A Sonic Comparator," which tests solid bodies for flaws and physical properties by principle of resonance vibration. Includes principle and basic applications.—Saturn Electronics Co., 8237 Witkop Ave., Niagara Falls, N. Y.

Circle 431 on inquiry card.

Dynamometer, Tester. Three new 6-page Bulletins (D4, 2, and LR2) illustrate and describe maker's "Model AN" dynamometer, "Model L" universal tester, and multi-low-range universal tester for tension, force, strain, etc.—W. C. Dillon & Co. Inc., P. O. Box 3008, 14620 Keswick St., Van Nuys, Calif.

Circle 432 on inquiry card.

Magnetic Drum Separator. New 6-page Bulletin B-601 illustrates and describes maker's permanent non-electric magnetic drum separators for the removel of ferrous materials from chemicals, food, etc. Includes dimensions and specifications.—Eriez Mfg. Co., Erie, Pa.

Circle 433 on inquiry card.

Spring Testing Machines. New 4-page Bulletin Be 20452 describes and illustrates maker's bench-model E1000 and floor-model E4000 "Elasticometer" testing machines. Also information on Models R-80du and RS-5 "Elasticometer" for testing compression and tension springs. Additional 8-page brochure introduces maker's new "Brirouv" hardness tester.—Testing Equipment Co., 15 William St., New York 5, N. Y.

Circle 434 on inquiry card.

Gages, Gage Blocks. New 4-page brochure describes and illustrates maker's gage blocks for industrial and scientific measurement. Includes micrometers, dynamometers, extensometers, and adjustable-limit snap gages. —Swedish Gage Co. of America, 10641 Haggerty Ave., Dearborn 1, Mich.

Circle 435 on inquiry card.

Recorders

Kymograph, Multi-speed-drive Applications. New Bulletin 53 illustrates and describes 26 novel applications of maker's drum and chart recorders and multi-speed drives in solving problems such as rate of plant growth, proportional mixing at low rates, unusual timing applications, etc.—Gorrell & Gorrell, Haworth, N. J.

Circle 436 on inquiry card.

Recording Potentiometers. Three new 4-page specification sheets describe and illustrate Brown "ElectroniK" recording potentiometers. Specification Sheet 160 covers circular chart recorders; Specification Sheets 164 and 165 cover single and multiple record strip-chart recorders. Construction and engineering details are included.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle 437 on inquiry card.

Recording Potentiometer. New 14-page Bulletin P-2-A illustrates and describes maker's new "Model 67001" recorder, a null-balancing (potentiometer) type employing line-driven synchronous converter and amplifier to control two-phase motor and rebalance measuring circuit. Includes features and construction.—Weston Electrical Instrument Corp., Newark 5, N. J.

Circle 438 on inquiry card.

Magnetic Recording. New 8-page brochure illustrates and describes maker's magnetic recording devices for use in recorders and also as a memory device. Includes specifications and operating data.—Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.

Circle 439 on inquiry card.

Magnetic Recorder. New 2-page illustrated bulletin presents maker's "Magnetic Mirragraph," a multiple-channel magnetic recorder-reproducer with one to 44 channels. Includes features and specifications.—Techno Instrument Co., 6666 Lexington Ave., Los Angeles, Calif.

Circle 440 on inquiry card.

Tape-Wire Recorders. New 2-page Bulletin 466 is maker's tape-wire recorder replacement guide listing replacement parts for 63 models of 22 companies manufacturing tape and wire recorders. Also 4-page Form 382 (revised edition of Williamson amplifier instruction sheet) introduces Craftsman-500 ultra fidelity amplifier and Craftsmen-800 tuner.—Standard Transformer Corp., 1 N. LaSalle, Chicago 2, Ill.

Circle 441 on inquiry card.

Recording Paper. New 12-page brochure describes and illustrates maker's new "Alfax" electrosensitive recording paper. Includes applications and characteristics.—Alfax Paper and Engrg. Co., P.O. Box 125, Westboro, Mass.

Circle 442 on inquiry card.

Monitoring Recorders. New 12-page brochure describes and illustrates maker's new magazine and multichannel recorders which use new electrosensitive paper and which operate without pen or ink, photographic delay, and monitor without inertia or moving parts. Includes applications and components.—Alden Electronic and Impulse Recording Equipment Co., P.O. Box 125, Westboro, Mass.

Circle 443 on inquiry card.

Recording Systems. New 6-page "Applicability Chart" presents de-

tailed specifications on maker's direct-writing recording systems, including performance, dimensions, weights, interchangeability, etc. Table presents types of transducers suitable for various measurements—temperature, pressure, flow, strain, etc.—Sanborn Co., 39 Osborn St., Cambridge 39, Mass.

Circle **444** on inquiry card.

Data Recording Camera. New 4-page brochure illustrates and describes maker's data-recording camera for aviation, industry, engineering, research, and development tests. Includes specifications.—Aremac Associates, 329 W. Washington St., Pasadena, Calif.

Circle **445** on inquiry card.

Humidity

Dewpoint Measuring Equipment. New 8-page Bulletin GEC 588A illustrates and describes maker's dewpoint measuring equipment for continuous indication and recording of moisture in a gas stream. Includes diagrams, applications, and operation principles. —General Electric Co., Schenectady 5, N. Y.

Circle **446** on inquiry card.

Humidity Measurement. New 4-page Data Sheet No. 10.5-4a describes new concept of humidity measurement that makes possible direct humidity readings from remote locations. Sta. 64, Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **447** on inquiry card.

Analytical Instruments

Mass Spectrometer. New 4-page Bulletin CEC-1824 describes and illustrates maker's "Model 21-610" mass spectrometer for lab and process monitoring. Includes principles and operation.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle **448** on inquiry card.

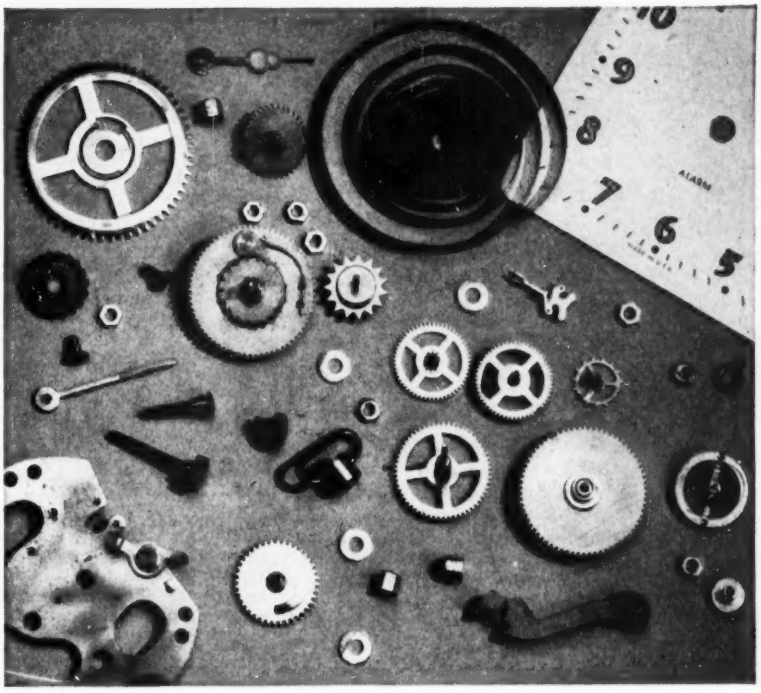
Spectrophotometers. New 28-page Catalog 303 describes and illustrates maker's ultraviolet and visible spectrophotometers, showing sample cells and other accessories.—Beckman Instrument Inc., S. Pasadena 1, Calif.

Circle **449** on inquiry card.

Spectrograph Equipment. New 12-page Catalog H-2 illustrates and describes maker's spectrograph outfits for "rapid economical analysis." Includes data on prism, automatic large, medium, intermediate, and small quartz spectrographs. Also notes on qualitative analysis and brief descriptions of other analytical instruments —X-ray diffraction, polarimeter, etc. —Jarrell-Ash Co., 165 Newbury St., Boston 16, Mass.

Circle **450** on inquiry card.

Analytical Calculator. New 4-page bulletin illustrates and describes



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maker's fan-scale calculator for converting spectrograph reading into relative intensities and then into concentrations. Includes theory, construction, and operation.—Jarrell-Ash Co., 165 Newbury St., Boston 16, Mass.

Circle 451 on inquiry card.

Railroad Spectograph. New 4-page bulletin illustrates and describes maker's special railroad spectograph in which precise spectrochemical analyses can be applied to the maintenance of diesel railroad engines. Includes technical features, lube oil analyses, and installation policy.—Jarrell-Ash Co., 165 Newbury St., Boston Mass.

Circle 452 on inquiry card.

Laboratory Apparatus

Warburg Apparatus. New 6-page bulletin describes and illustrates maker's "Bronwill" Warburg Apparatus for precise microgas analysis, including units with and without fluorescent tubes for photosynthesis. Also described are Warburg apparatus "Circular Models UV and UVL," and double-capillary manometers.—Bronwill Scientific, Inc., 40 Worth St., New York 13, N. Y.

Circle 453 on inquiry card.

Laboratory Instruments. New 16-page illustrated "Laboratory Spotlight" No. 9 includes 6 pages of new "Micro" instruments (infrared spectrophotometer, viscosimeter, etc.) and 2 pages of new "Labline" furniture.—Harshaw Scientific, Div. of Harshaw Chemical Co., Cleveland 6, Ohio.

Circle 454 on inquiry card.

Crystal Model Kit. New 4-page Bulletin D-3040 presents maker's new crystal model kit which demonstrates crystal structure in three dimensions. Includes prices.—Harshaw Scientific, Harshaw Chemical Co., Cleveland 6, Ohio.

Circle 455 on inquiry card.

Glass Apparatus. New 34-page Catalog 22 illustrates & describes standard and special scientific glass apparatus; scintillation crystals and liquids; special chemicals, gases and accessories; and thin films.—Wakefield Industries, Dept. FP-3, 5108 W. Grove St., Skokie, Ill.

Circle 456 on inquiry card.

Wrist-action Shaker. New 4-page Bulletin 307 describes and illustrates maker's wrist-action shaker.—Burrell Corp., 2223 Fifth Ave., Pittsburgh 19, Pa.

Circle 457 on inquiry card.

Tube, Box Furnaces. New 4-page Bulletin 310 describes and illustrates maker's electric, unit-package tube furnaces. Bulletin 315 covers box and muffle furnaces.—Burrell Corp., 2223 Fifth Ave., Pittsburgh 19, Pa.

Circle 458 on inquiry card.

Laboratory Chemicals. New 28-page issue of "Chemist Analyst" Vol. 42, No. 1 features article on determination of nitrogen by conductivity measurements of ammonium borate-boric acid solutions. Also article on use of aluminum foil in the laboratory.—J. T. Baker Chemical Co., Phillipsburg, N. J.

Circle 459 on inquiry card.

Distillation Equipment. New 4-page price list Form 4FE253 covers maker's perforated bubble-plate columns, packing-type columns, concentric-tube column units, etc., for fractionating distillation equipment.—Glass Engineering Laboratories, 609 O'Neill Ave., Belmont, Calif.

Circle 460 on inquiry card.

Laboratory Heater. New 4-page Bulletin 400 describes maker's new "Forma-Heater" for laboratory applications. Includes applications and models.—The Forma-Heater Co., 738 7th St., Marietta, Ohio.

Circle 461 on inquiry card.

Thermo Laboratory Apparatus. New 14-page pamphlet contains descriptions of three of maker's instruments: hot benches for determination of melting points, hot and cooling stages for microscopic observation at controlled temp., and hot and cooling stage microscopes.—Wm. J. Hacker & Co., Inc., 82 Beaver St., New York 5, N. Y.

Circle 462 on inquiry card.

Camera Microscope. New 2-page release illustrates and describes the Reichert universal camera microscope Model MeF." Includes operation and accessories list.—William J. Hacker & Co. Inc., 82 Beaver St., New York 5, N. Y.

Circle 463 on inquiry card.

Spectrometer, Automatic Pipette. New 2-page brochure describes and illustrates maker's "Spectron" comparison spectrometer and visual colorimeter. Four-page brochure describes 4-in-1 electronic "Filamatic" pipette, pump, and filling machine.—National Instrument Co., 5005 Queensbury Ave., Baltimore 15, Md.

Circle 464 on inquiry card.

Optical

International Color System. New 36-page booklet explains the international color system and shows its value for color specification in industry.—Curry & Paxton Inc., 101 Park Ave., New York 17, N. Y.

Circle 465 on inquiry card.

Infrared Lenses, Windows. New 2-page illustrated brochure presents properties, features, and indices of refraction of new "Servofrax" infrared lenses and windows made of arsenic trisulfide glass.—Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y.

Circle 466 on inquiry card.

Radioactivity

Radiation Detection and Counting. New 28-page Catalog lists maker's complete line of radiation detection and counting instruments. Features

proportional counters and proportional counter converters.—Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

Circle **467** on inquiry card.

Radioactivity Instruments. New 4-page price list includes prices of Victoreen radiation instruments, vibrators, hi-meg resistors, etc.—Terminal Radio Corp., 85 Cortlandt St., New York 7, N. Y.

Circle **468** on inquiry card.

Timing, Counting

Precision Timers. New 16-page Booklet 198 illustrates and describes maker's precision timers, millisecond timers, cycle counters, and panel mounted clocks. Includes external connections, coil data, and wiring diagrams.—The Standard Electric Time Co., Springfield 2, Mass.

Circle **469** on inquiry card.

Time Totalizer. New 2-page Bulletin 5M illustrates and describes maker's "Model ET" time totalizer for measurements of elapsed time intervals. Includes application, specifications, and dimensions.—R. W. Cramer Co., Centerbrook, Conn.

Circle **470** on inquiry card.

Timing Devices. New 10-page brochure introduces maker's electronically vibrated hairsprings for precision time control and timing devices, for manufacturers of thermostats, speedometers, parking meters, watches, etc. —Hairspring Vibrating Co., 406 32 St., Union City, N. J.

Circle **471** on inquiry card.

Photoelectric Counter. New release describes maker's new industrial photoelectric counter, magnetic amplifier type, for use as door control, burglar alarm, flame, failure device, etc.—Federal Telephone and Radio Corp., 100 Kingsland Rd., Clifton, N. J.

Circle **472** on inquiry card.

Computing

Analysis Computer. New 4-page bulletin illustrates and describes maker's new "Complex Plane Analyzer" computer for network analysis and control system design, which automatically multiplies and divides complex vectors, solves magnitude and phase-angle frequency-response problems, etc. Includes uses, and performance results.—Technology Instrument Corp., Acton, Mass.

Circle **473** on inquiry card.

Angular Position Encoder. New 2-page Bulletin 109 illustrates and describes maker's new "Models 14310 and 14311" angular position encoders for translating angular position of shaft, rheostat, etc. into digital data. Includes specifications, features.—G. M. Giannini & Co., Inc., Pasadena 1, Calif.

Circle **474** on inquiry card.

Db Slide-rule Chart. New slide-rule chart rapidly converts db to current, voltage, or power ratio, or vice versa. Also performs square, square root, and

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"700" RECORDERS

RACK MOUNTED 712-B (12") RECORDER...Operation, control, loading and adjustments from *Front Surface.*

...the *only* oscillograph recorder using 12" recording media that can be conveniently mounted in a 19" relay rack. All operating controls are on one surface. Loading and unloading can be accomplished easily and quickly from this same surface. Input connectors can be supplied as shown or installed on the top end of the recorder, leaving the operating panel free of cabling. "700" recorders can be supplied in 115 Volt, 60 cycle and 23.5—28.5 Volt D.C. Models.

Exclusive Heiland Features **Designed for rack or table mounting • Operation, control, loading and maintenance from one surface • Direct monitoring of galvanometer light spots while recording • Damping resistor panel • Automatic light adjustment with record speed change.**

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Write for catalog giving complete information on the Heiland "700" recorders and other multi-channel recorders, accessories and galvanometers...

OPEN VIEW OF 708-B (8") recorder showing supply and take-up drums, operating controls.

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500-B—Portable oscillograph recorder. Compact and lightweight providing maximum portability and versatility where it is desired to record up to 12 phenomena. 4" x 100' recording paper, 23.5—28.5 Volt D.C.

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MANUFACTURERS' NEW LITERATURE

log functions.—Ballantine Laboratories, Inc., Boonton, N. J.

Circle 475 on inquiry card.

Character-display Signal Generator. New 2-page brochure illustrates and describes maker's "Model DS-157" character-display signal generator, for electronic computers and data processing, which displays numerals on face of any cathode-ray tube at rate of 10,000 per second.—Wang Laboratories, 296 Columbus Ave., Boston 16, Mass.

Circle 476 on inquiry card.

Analog Multiplier Tube. New 2-page data sheet describes maker's new "Multron" vacuum tube that uses thermal elements for multiplying and dividing analog quantities. Illustrated data sheet presents "Model 207" electronic chopper, a new low-level signal converter.—Avion Instrument Corp., Highway 17, Paramus, N. J.

Circle 477 on inquiry card.

Electronic Computers. New 4-page illustrated bulletin describes maker's "Elecom" digital-tape electronic computers for business, industry, science, and research. Includes specifications and applications.—Electronic Computer Div., Underwood Corp., 35-10 36th Ave., Long Island City, N. Y.

Circle 478 on inquiry card.

Mechanized Accounting. New 6-page folder illustrates and describes maker's means of keeping customers records up-to-date, making detailed distributions with less effort, and maintaining accounting control at all times by means of mechanized accounting.—Remington Rand Inc., 315 Fourth Ave., New York 10, N. Y.

Circle 479 on inquiry card.

Radio, TV

Carrier Terms. New 16-page Bulletin EB-101 "Dictionary of Carrier Terms" includes definitions of 150 terms commonly found in telephone and telegraph equipment literature. Also discussion of carrier equipment theory.—Lenkurt Electric Co., 1188 County Road, San Carlos, Calif.

Circle 480 on inquiry card.

TV Troublefinder Guide. New 8-page "Pix-O-Fix" lists typical TV trouble symptoms, possible causes, and remedies. Has accompanying circular dial containing 24 typical patterns, each of which has a key number to guide reader to accompanying remedy. Price $1.00.—Rinehart Books, Inc., 232 Madison Ave., New York 16, N. Y.

Circle 481 on inquiry card.

Radio, Television Products. New 64-page Catalog 155 and 16-page Supplement 153 presents maker's line of radio and television products. Includes radio chemicals, radio and TV parts, service aids, alignment and radio tools, etc.—General Cement Mfg. Co., Rockford, Ill.

Circle 482 on inquiry card.

TV Ion Traps. March '53 issue of "Sylvania News" features article on ion-trap magnets by G. E. Fogg. Also a new TV station time table.—Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N. Y.

Circle 483 on inquiry card.

Waveguide Assemblies. New 4-page brochure illustrates and describes maker's typical waveguide assemblies for use in military radar, guided missiles, and telecommunication.—N.R.K. Mfg. & Eng. Co., 4601 W. Addison St., Chicago 41, Ill.

Circle 484 on inquiry card.

Servos

Electromechanical Servo Components. New 30-page catalog describes and illustrates maker's couplings, spacers, collars, hangers, magnetic clutches, stops, gears, and other electromechanical components for servo assemblies.—Belock Instrument Corp., College Point, N. Y.

Circle 485 on inquiry card.

Synchros, Servos, Resolvers. New 42-page bulletin illustrates and describes maker's line of synchros, servos, and resolvers. Includes applications, characteristics, and operation.—Ketay Mfg. Corp., 555 Broadway, New York 12, N. Y.

Circle 486 on inquiry card.

Electrical & Electronic Test Instruments

Oscillography. New 24-page issue Vol. 13, No. 4 of "The Oscillographer" features article on the function and design of transducers for oscillography by Mark T. Nadir. Also articles on a simplified phase-shift test and hardness testing with cathode-ray oscillographs.—Allen B. DuMont Laboratories, Inc., Instrument Div., 1500 Main Ave., Clifton, N. J.

Circle 487 on inquiry card.

Test Instruments. New 8-page "Short Form" Catalog 5302 presents features and specifications of maker's line of oscilloscopes, generators, and amplifiers.—Tektronix, Inc., P.O. Box 831, Portland 7, Ore.

Circle 488 on inquiry card.

Electronic Test Instruments. New 8-page folder Form 2604 describes and illustrates maker's electronic test instruments, including new oscillators, counter and signal generators, and improved waveguide equipment.—Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif.

Circle 489 on inquiry card.

Electronic Equipment. New 8-page issue of "The General Radio Experimenter" Vol. 27, No. 10 features article on "Transistor Measurements with the Vacuum-tube Bridge." Also article on portable test autotransformers.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle 490 on inquiry card.

Null Detector. New 8-page issue of "The General Radio Experimenter" Vol. 27, No. 9 describes and illustrates maker's "Type 1212-A" unit null detector for use as bridge-balance detector. Includes articles on "Type 1212-P1" high-pass filter, "Type 1951-A" filter, measurement of cable characteristics, and "universal" coaxial adaptors.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle **491** on inquiry card.

Electronic Equipment. New 8-page Bulletin 10M 3-53 illustrates and describes maker's equipment for a completely integrated line based on new concept of adapting all electronic equipment to plug-in unit construction. Includes 12 designs.—Alden Products Co., 117 N. Main St., Brockton 64, Mass.

Circle **492** on inquiry card.

Inverter Amplifier. New 4-page brochure introduces maker's new "Model 305" inverter amplifier for a-c. amplification of low-level d-c. signals. Includes specifications.—Allegany Instrument Co., 1000 Oldtown Road, Cumberland, Md.

Circle **493** on inquiry card.

Electronic Instruments. New 40-page Catalog "J" Form 8900 describes and illustrates maker's line of instruments for measurement of circuit components, FM-AM signal generators, aircraft navigation and landing-system signal generators, and accessories. Includes features and specifications.—Boonton Radio Corp., Boonton, N. J.

Circle **494** on inquiry card.

Gaussmeter. New release describes and illustrates maker's new rotating-coil gaussmeter for measurements of magnetic field strengths in air gaps.—Rawson Electrical Instrument Co., 110 Potter St., Cambridge 42, Mass.

Circle **495** on inquiry card.

Sensitive Inverter. New bulletin illustrates and describes maker's new "Model 700" sensitive inverter for measurement of d.c. down to 1 microvolt. Includes applications, specifications, and use with VTVM, oscilloscope, etc.—Ballantine Laboratories, Inc., Boonton, N. J.

Circle **496** on inquiry card.

Ruggedized Meters. New 4-page Form RM4523 describes and illustrates maker's ruggedized meters that meet military specifications.—Hickock Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, Ohio.

Circle **497** on inquiry card.

Electrometers. New 8-page Bulletin 305 describes and illustrates maker's vacuum-tube electrometers for use as voltmeters where only minute currents can be drawn from source. Includes 19 application diagrams and specifications.—Keithley Instruments, 3868 Carnegie Ave., Cleveland 15, Ohio.

Circle **498** on inquiry card.

Electronic Wattmeter. New 2-page Bulletin 304 describes and illustrates

Scientifically controlled tests, impartially conducted, to determine the comparative accuracy of several flowmeters of popular designs have conclusively proved the superior advantages of Barton's Dual-Bellows meter body. The Barton was the only flowmeter that averaged less than 1% deviation from perfect calibration over a 100°F change in meter temperature; others tested deviated as much as 3%. The ingeniously engineered Barton Meter Body insures a higher order of accuracy when the instrument is subjected to normal day and night air temperature variations.

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MANUFACTURERS' NEW LITERATURE

maker's "Model 110" electronic wattmeter with range from 0.3 to 9000 watts, and response from 20 to 3000 cps. Includes specifications and features.—Keithley Instruments, 3868 Carnegie Ave., Cleveland 15, Ohio.

Circle **499** on inquiry card.

Direction Finder, Preamp. New 4-page illustrated brochure presents maker's new "Model DFG-2" high-frequency direction finder and "Model DFM-2" mobile DF unit. New 2-page brochure presents new "Servotherm Model 1322" low-frequency preamplifier.—Servo Corp. of America, 20-20 Jericho Pike, New Hyde Park, N. Y.

Circle **500** on inquiry card.

Tuning Fork Resonator. New 4-page Illustrated Folder 102 presents new "Model J" miniaturized, precision tuning-fork resonator for precision frequencies from 100 to 2,000 cps, and with Q of 10,000. Includes features, installations, construction, and schematic.—Philamon Laboratories, Inc., 5717 Third Ave., Brooklyn 20, N. Y.

Circle **501** on inquiry card.

Electrical Instruments. New 4-page issue of "Electrical Instruments" Vol. 20 No. 2 features article on design and construction factors in accurate lab-type ammeters.—Sensitive Research Instrument Corp., 9-11 Elm St., Mount Vernon, N. Y.

Circle **502** on inquiry card.

Conductance Curve Design. New 22-page "The Conductance Curve Design Book" by Keats A. Pullen shows how design and test time on electronic circuits can be reduced by use of conductance curves. Price $1.00—Kann-Ellert Electronics, 9 S. Howard St., Baltimore 1, Md.

Circle **503** on inquiry card.

Electronic Instruments for Medical Research. New 8-page illustrated brochure presents maker's amplifiers, oscilloscopes, power supplies, square-wave stimulators, and battery floater with special provision (d-c. coupling, etc.) for physiological and medical research. New 12-page brochure illustrates and describes design and development facilities for research and production of electronic and electromechanical instruments.—American Electronic Laboratories, Inc., 641 Arch St., Phila. 6, Pa.

Circle **504** on inquiry card.

X-band Test Equipment. New 4-page bulletin describes and illustrates maker's "Model 109" multi-purpose X-band test equipment. Includes features and specifications for use as generator, wavemeter, spectrum analyzer, etc.—Century Electronics, 14806 Oxnard St., Van Nuys, Calif.

Circle **505** on inquiry card.

Magnetic Amplifier. New 4-page bulletin describes maker's new self saturable magnetic amplifier. Includes features, specifications.—Ketay Mfg. Corp., 555 Broadway, New York 12, N. Y.

Circle **506** on inquiry card.

Test Instruments. Set of 12 illustrated bulletins describe maker's line of electronic test instruments—amplifiers, preamplifiers, cathode followers, filters, blast gauges, accelerometers, and delay lines.—Gulton Mfg. Corp., Metuchen, N. J.

Circle **507** on inquiry card.

Power-frequency Amplifier. New bulletin illustrates and describes maker's "Model 105 Meter Matcher" for measuring circuits affected by meter currents, aids measurements of fluorescent lamp circuits and synchro outputs, and as a signal amplifier with calibrated gains for resistive loads. Includes operation, and specifications. —Keithley Instruments, 3868 Carnegie Ave, Cleveland 15, Ohio.

Circle **508** on inquiry card.

Pass-Reject Amplifier. New 16-page issue of the "CD Capacitor" Vol. 18 No. 2 features article on a high-selectivity pass reject amplifier for use in the communications and electronic fields. Includes the "Radio Trading Post," for those who want to buy,

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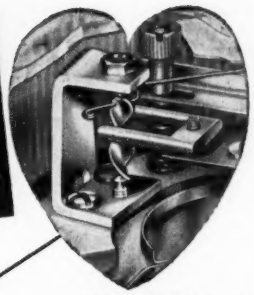

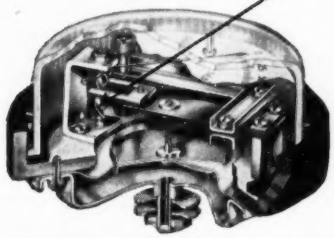

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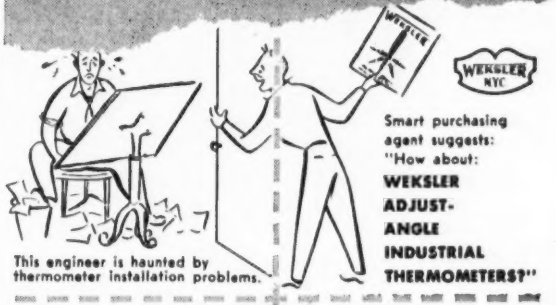

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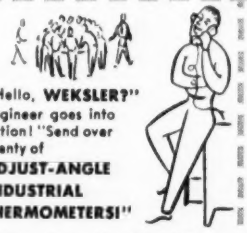

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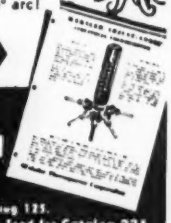

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sell, or swap radio equipment.—Cornell-Dubilier Electric Corp., Hamilton Blvd., S. Plainfield, N. J.

Circle 509 on inquiry card.

TV Interference Filters. New 24-page issue of "Cornell-Dubilier Capacitor," Vol. 18, No. 1 features article on TV interference filters. Includes descriptions and specifications of maker's capacitors, and a trade-and-sale section.—Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

Circle 510 on inquiry card.

Unit Oscillator. New 8-page issue Vol. 27, No. 8 of "General Radio Experimenter" features article on a new 50-250-Mc. unit oscillator. Also includes articles on power-factor measurements on transformer oil, simple harmonic motion, and air currents made visible.—General Radio Co., Cambridge, Mass.

Circle 511 on inquiry card.

Printed, Packaged Circuits

Miniaturized Packaged Circuitry. New 44-page Catalog 52-8 presents features, applications, and specifications of maker's miniature packaged plug-in circuits—scalers, multivibrators, triggers, amplifiers, etc.—Audio Products Corp., 2265 Westwood Blvd., Los Angeles 64, Calif.

Circle 512 on inquiry card.

Printed Circuits. New 4-page Bulletin 1151-A describes maker's printed circuits—integrators, couplers, etc.—Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.

Circle 513 on inquiry card.

Printed Circuits. New 8-page bulletin introduces maker's printed circuits which serve as connecting medium for electrical components. Includes characteristics, printed components, flush circuit patterns, and assembly.—Photocircuits Corp., Glen Cove, N. Y.

Circle 514 on inquiry card.

Automatic Scaler. New 2-page release presents maker's "Model A-63" automatic scaler, a general-purpose laboratory instrument and count-rate meter. Includes specifications, accessories.—Atomlab Inc., 489 Fifth Ave., New York 17, N. Y.

Circle 515 on inquiry card.

Power Supplies

AC Line Regulators, Frequency Changers. New 16-page Catalog 353 includes information on maker's line of electronic AC line regulators, including principle, features, and operation. Also gives descriptions and specifications for electronic frequency changers with 60-cps. input and 400-cps. output.—Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn.

Circle 516 on inquiry card.

Constant-voltage Transformers. New 24-page Bulletin CV-142 illustrates and describes maker's constant-voltage transformers for static magnetic voltage regulation. Includes applications, specifications, and dimensional diagrams.—Sola Electric Co., 4633 W. 16 St., Chicago 50, Ill.

Circle 517 on inquiry card.

Power Conversion Units. New 8-page Bulletin GEA-5658B illustrates and describes maker's metallic-rectifier power conversion units rated from 125 to 250 volts d-c. Includes drawings, specifications, and dimensions.—General Electric Co., Schenectady 5, N. Y.

Circle 518 on inquiry card.

Power Supplies. New 10-page release illustrates and describes makers line of electronically regulated and unregulated laboratory power supplies. Includes characteristics and electrical specifications.—Lambda Electronics Corp., Corona, N. Y.

Circle 519 on inquiry card.

Absolute DC Power Supplies. New 6-page brochure illustrates and describes maker's new chopper-stabilized regulator system which uses standard cell and a-c. amplifier to achieve 0.01-percent regulation. Includes principle, specifications, and construction.—Kalbfell Laboratories, Inc., 1090 Morena Blvd., San Diego 10, Calif.

Circle 520 on inquiry card.

Klystron Power Supplies. New 4-page Bulletin KPS-1 illustrates and describes maker's Models 910 and

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MANUFACTURERS' NEW LITERATURE

2310 electronically regulated Klystron power supplies which deliver all voltages and currents for operation of most types of Klystron tubes. Includes features and specifications.—Furst Electronics, 3322 W. Lawrence Ave., Chicago 25, Ill.

Circle 521 on inquiry card.

Selenium Rectifiers. New 4-page bulletin describes and illustrates maker's new "Plastisel" miniature electronic selenium rectifiers.—Electronic Devices Inc., 429 12th St., Brooklyn 15, N. Y.

Circle 522 on inquiry card.

Power-supply Regulator. New 2-page release describes maker's "Model 121 Kay-Lab Super Regulator" with low internal impedance, low noise, and maximum flexibility. Includes operational controls, specifications, and tube complement.—Kalfbell Laboratories, Inc., 1090 Morena Blvd., P. O. Box 1578, San Diego 10, Calif.

Circle 523 on inquiry card.

Selenium Rectifiers. New bulletin illustrates and describes maker's selenium rectifiers, hermetically-sealed cartridge types, from 40-microamp. to 140,000 amps.—International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

Circle 524 on inquiry card.

Aircraft Ground Power. New series of revised catalog pages and folders, describes products and applications of various types of aircraft ground power equipment. Includes data on engine generator, trailer, regulated rectifiers (both mobile and stationary) and load-sensitive governor.—Inet, Inc., 8655 S. Main St., Los Angeles 3, Calif.

Circle 525 on inquiry card.

Ballast Regulating Tube. New 4-page Bulletin AB-51 illustrates and describes maker's ballast-regulating tube for keeping circuit current at a definite value. Includes effects, characteristics, capacities available, and typical regulating problems.—Amperite Co., Inc., 561 Broadway, New York 12, N. Y.

Circle 526 on inquiry card.

Alternator Power Supply. New bulletin describes maker's 400-cycle inductor-alternator portable power-supply. Includes input and output requirements, styles available, and suggested applications.—Inet, Inc., 8655 South Main St., Los Angeles 3, Calif.

Circle 527 on inquiry card.

Plug-in Power Supply. New bulletin illustrates and describes maker's "Mini-Pack" plug-in selenium-rectifier power supply. Includes features and specifications.—Jersey City Technical Laboratory, 880 Bergen Ave., Jersey City, N. J.

Circle 528 on inquiry card.

Selenium Rectifier. New 4-page Bulletin 271 includes 3 insert pages and illustrates and describes maker's rectifier which converts a-c. power to d-c. Includes types and sizes available. —American Rectifier Corp., 103 Walker St., New York 13, N. Y.

Circle 529 on inquiry card.

Relays, Switches

Sealed Relays. New 4-page Bulletin GEA-5729A illustrates and describes maker's hermetically-sealed relays, including specification charts, dimensional diagrams, application, performance, and features.—General Electric Co., Schenectady 5, N. Y.

Circle 530 on inquiry card.

Relays. New 2-page issue of "Relay Hightlights, No. 1" illustrates and describes maker's hermetically sealed "Series SQA" relays, including specifications.—Automatic Electric Sales Corp., 1033 W. Van Buren St., Chicago 7, Ill.

Circle 531 on inquiry card.

Thermal Relays. New 4-page bulletin illustrates and describes maker's miniature and octal size thermal time delay relays of the hermetically-sealed adjustable type. Includes cut-away views, a complete set of curves of operating characteristics, and detailed specifications.—G-V Controls Inc., 28 Hollywood Plaza, E. Orange, N. J.

Circle 532 on inquiry card.

Delay Relay. New 4-page Bulletin TR-81 illustrates and describes maker's thermostatic delay relay for use with a.c., d.c., or pulsating current. Includes diagrams, specifications, and circuits available.—Amperite Co., Inc., 561 Broadway, New York 12, N. Y.

Circle 533 on inquiry card.

Circuit Breakers. New 16-page Manual 101 explains and diagrams the operating principles of the 3 basic types of circuit breakers—thermal, thermal-magnetic, and magnetic. Discusses temperature factors, inrush current effects, tripping, andreset time.—Heinemann Electric Co., 305 Plum St., Trenton 2, N. J.

Circle 534 on inquiry card.

Control Relay. New 4-page Booklet B-5817 illustrates and describes maker's new "Type N" control relay for pilot circuits, automatic control, and sequencing operations. Includes specifications.—Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

Circle 535 on inquiry card.

Relays. New 16-page Catalog 53-1 describes and illustrates maker's line of sensitive relays for utilizing weak electrical signals to control circuits carrying larger amounts of power. Include features, applications, and standard adjustments.—Sigma Instruments, Inc., 62 Ceylon St., Boston, Mass.

Circle 536 on inquiry card.

Toggle Switches. New 2-page Data Sheet 70a describes and illustrates maker's bushing mounted, single-pole toggle switches.—Micro Div., Minneapolis-Honeywell, Freeport, Ill.

Circle **537** on inquiry card.

Switches. New 4-pages of catalog inserts illustrate and describe maker's "Vac-on" switch which prevents breakdowns due to dry operation of electric- or gasoline-driven pumps and equipment.—Jaycon Associates, 404 Washington Ave. N., Minneapolis 1, Minn.

Circle **538** on inquiry card.

Transistors, Tubes

Transistors. New 24-page Bulletin DIM 3-23-53 presents history of transistors and their applications in circuits. Includes origin, different types developed, how it works, and how it is made.—Radio Corporation of America, RCA Building, 30 Rockefeller Plaza, New York 20, N. Y.

Circle **539** on inquiry card.

Transistors. New Bulletin 3F966 describes and illustrates maker's new point-contact and junction-type transistors. Includes biasing, characteristics.—Radio Corp. of America, Tube Dept., Harrison, N. J.

Circle **540** on inquiry card.

Electron Tube Interchangeability. Leaflet Form 253 gives interchangeability data on a series of maker's electron tubes.—Lewis and Kaufman, Ltd., 110 El Rancho Ave., Los Gatos, Calif.

Circle **541** on inquiry card.

Miniature Cathode-ray Tube. New 4-page leaflet 2.511 presents new English-made "Cossor Type 1CP1" miniature self-focusing cathode-ray tube for monitoring applications.—Beam Instruments Corp., Empire State Bldg., New York 1, N. Y.

Circle **542** on inquiry card.

Electron Tube Life. New 4-page Leaflet 153 features a summary of data-sheet rating interpretations and a series of notes concerning means of improving electron-tube service life.—Lewis and Kaufman Ltd., 110 El Rancho Ave., Los Gatos, Calif.

Circle **543** on inquiry card.

Transistors. New 8-page brochure describes first commercially available junction-type transistors, UHF television antennas and set convertors, TV-FM booster wire, tubes, blowers, and transformers available from distributor.—Radio Shack Corp., 167 Washington St., Boston 8, Mass.

Circle **544** on inquiry card.

Miniature Electron Tubes. New 8-page reference guide is 6th edition of maker's list of miniature electron tubes, including all makes. Includes characteristics for 250 miniatures (87 new since fifth edition). Also includes 111 basing diagrams and indicates similar larger prototypes.—Hytron Radio & Electronics Co., Div. of CBS Inc., Danvers, Mass.

Circle **545** on inquiry card.

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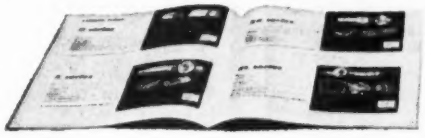
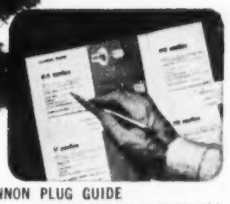
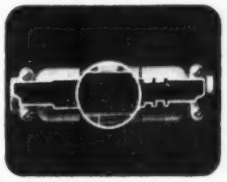
A color film with schematic animation and supporting narration... to help you select connectors engineered to your requirements and operating conditions. Disconnect system? Number of contacts? Voltage? Amperage? These and other factors are covered in this helpful film. In addition you'll learn how the printed Cannon Plug Guide (below) leads you to the *right* connector for any job. Request your free showing today.

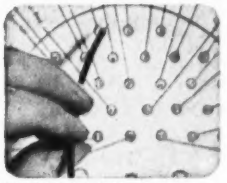




CANNON PLUG GUIDE
. . . An easy-to-follow graphic aid.



CURRENT CAPACITY
and its relation to contact spacing.



SPACING AND NUMBER
of contacts involves many factors.

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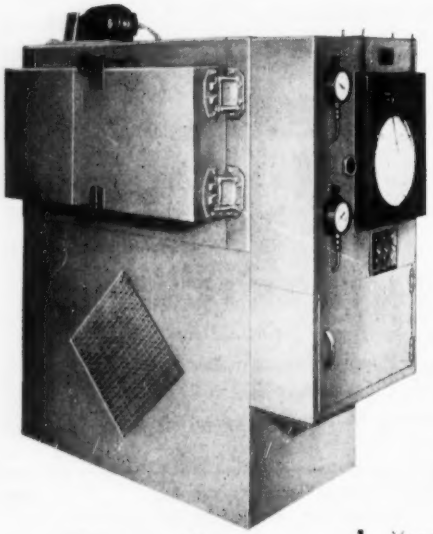

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NEW LITERATURE

Receiving Tubes. New 24-page quick-reference booklet for servicemen, technicians, engineers, students, amateurs, etc., covers more than 495 receiving tubes with reference to the characteristics, and socket connections for each tube type, as well as a classification chart for selection of the proper tube type for a desired purpose.—Commercial Engineering, RCA Tube Dep't., Harrison, N. J.

Circle 546 on inquiry card.

Connectors

Connector Assembly Procedures. New 40-page "OK Methods" Manual C3 of recommended assembly and wiring procedures contains proper detailed techniques for cutting, stripping, soldering and assembly of wire and cable to AN, RF, and special-type electrical connectors.—American Phenolic Corp., 1830 S. 54 Ave., Chicago 50, Ill.

Circle 547 on inquiry card.

Sub-miniature Connectors. New 4-page Bulletin U-3 describes and illustrates maker's type "U" subminiature connectors for use on miniature sealed and unsealed instrument switches, relays, transformers, etc.—Cannon Electric Co., 3209 Humboldt St., Los Angles 31, Calif.

Circle 548 on inquiry card.

Miniature Coax Assembly. 4-page Publication 253 illustrates and describes new "Microdot" miniature coaxial assemblies and "Mininoise" cable for high-impedance pickup.—Microdot Div., Felts Corp., 1826 Fremont Ave., S. Pasadena, Calif.

Circle 549 on inquiry card.

Miniature Connectors. New 2-page Bulletin CR5-2 illustrates and describes maker's miniature pressure-tight multi-contact connectors. Includes application and specifications.—Winchester Electronics, Inc., Glenbrook, Conn.

Circle 550 on inquiry card.

Resistors, Potentiometers

Precision Potentiometer. New 2-page Bulletin 121 describes and illustrates maker's "Model YS" 2-gang precision single-turn potentiometer. Includes specifications and power rating.—Helipot Corp., South Pasadena, Calif.

Circle 551 on inquiry card.

Precision Potentiometers. New 6-page illustrated brochure describes maker's "Unitized" precision potentiometers for use with guided missiles, flight trainers, analog computers, etc. Includes specifications, dimensions.—Servotrol Co., 114 W. Illinois St., Chicago 10, Ill.

Circle 552 on inquiry card.

Resistors, Components. New 2-page Feb. '53 issue of "The Ohmite News" features article on solving switching problems with maker's rotary tap

switches. Also data on rheostats and "Brown Devil" resistors.—Ohmite Mfg. Co., 4835-41 Flournoy St., Chicago 44, Ill.

Circle 553 on inquiry card.

Decade Resistor. New 2-page bulletin illustrates and describes maker's "Model 7" decade resistor for determining proper RTMA resistance values. Includes characteristics.—Rochester Electronics Co. Inc., P. O. Box 227, Penfield, N. Y.

Circle 554 on inquiry card.

High-Impedance Components. New 8-page Catalog 3016 contains specifications, illustrations, typical circuits, and applications for maker's components which include vibrators, electrometer tubes, voltage regulators, current regulator tubes, hi-meg resistors, etc.—Victoreen Instrument Co., Components Div., 3800 Perkins Ave., Cleveland 14, Ohio.

Circle 555 on inquiry card.

Magnets, Materials

Standard Permanent Magnets. New 16-page Catalog SM-1252 lists maker's complete line of standard permanent magnets for use in industrial applications. Includes dimensions and tolerances.—Thomas & Skinner Steel Products Co., Inc., 1164 E. 23 St., Indianapolis 5, Ind.

Circle 556 on inquiry card.

Tape-Wound Cores. New 28-page Bulletin TC-101A lists 22 standard core sizes, guaranteed minimum core weights, and explanation of magnetic test conditions. Includes magnetization curves and typical properties of Deltamax, 4-79 Mo-Permalloy, and Supermalloy.—Arnold Engineering Co., Marengo, Ill.

Circle 557 on inquiry card.

Piezoelectricity, Transducers

Piezotronics. New 28-page Technical Bulletin CD43001 presents characteristics and applications of piezoelectric materials, design data, and equivalent-circuit data. Includes cuts, designations, applications, impedance considerations, bimorphs, driving devices, and conversion charts.—Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.

Circle 558 on inquiry card.

Piezotronics. New 20-page Brochure CD23001 illustrates and describes use of piezotronics as applied to the generator function, the motor function, electric storage, optical, condenser, and impedance functions.—Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.

Circle 559 on inquiry card.

Transducers. New loose-leaf brochure contains 9 illustrated data sheets on maker's linear displacement transducers, pressure transducers, accelerometers, and strain gages. Includes principles and specifications.—Scientific Enterprises, 832 N. La Brea Ave., Hollywood 38, Calif.

Circle 560 on inquiry card.

Air, Filters

Pipe Line Filter. New 4-page illustrated Bulletin 210 describes four new low-pressure pipe-line filter models

When designing any plug-in unit REACH FOR THIS BASE

ALDEN 20-PIN Also 11-pin & MIN. 7 & 9-pin

Molded boss to hold mounting cards.

Holes to take brackets or bail, kept well away from corners.

All prongs numbered.

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Bases are complemented by standard Alden components: handles, brackets, housings, terminal cards to lick almost any problem.

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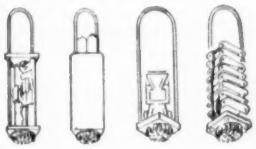
Choice of variable pin patterns guarantees against mismating. Color coding directs plug-in to its correct socket.



11 to 20 pins in many patterns.

Rack-mounting Sockets to match Base patterns

Also 20-pin, 11-pin, 9-pin, 7-pin MATING SOCKETS Request free samples and free 226-page "Alden Handbook" of Plug-in Unit Construction.

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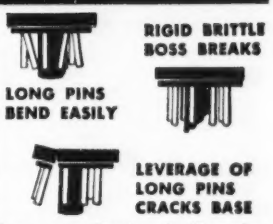

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LEVERAGE OF LONG PINS CRACKS BASE

Are you tired of throwing away perfectly good units on account of broken bases?

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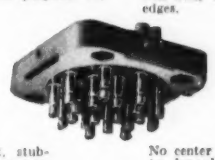
Ruggedly designed for specific purpose. ...

Mounting holes well away from edges.



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For further information circle 176 on inquiry card.

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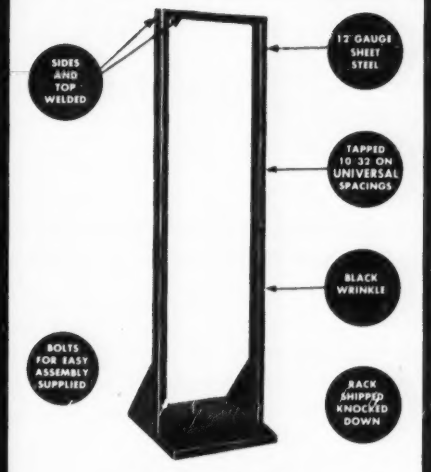
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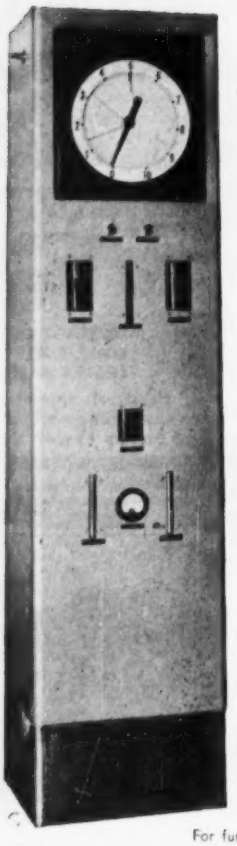

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INSTRUMENT DAVIS DIVISION

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JOHN R. MONSELL
Manufacturing Engineer
Pitman, N. J.

For further information circle 179 on inquiry card.

NEW LITERATURE

for removal of vapor and dirt from compressed air lines. Includes specifications and engineering and performance data.—Dollinger Corp., 11 Centre Pk., Rochester 3, N. Y.

Circle 561 on inquiry card.

Dehumidifiers. New 4-page Bulletin DD-150 illustrates and describes maker's "Dynamic" dehumidifiers—closed regeneration systems for compressed gasses. Includes flow diagrams and model nomenclature.—Industrol Corp., 472 Westfield Ave. East, Roselle Park, N. J.

Circle 562 on inquiry card.

Air Filter. New 2-page brochure describes and illustrates maker's "Model B-30-D Condensifilter" for providing instrument-quality air for compressed air applications.—Hankison Corp., 195 Biltmore Bldg., 951 Banksville Rd., Pittsburgh 19, Pa.

Circle 563 on inquiry card.

Air, Gas Purifiers. New 8-page illustrated Bulletin 501 describes maker's line-type "Hi-eF Purifiers," mechanical separators that remove 99 percent of dirt and moisture from air and gas lines. Includes principles, piping layouts, selection data, etc.—The V. D. Anderson Co., 1935 W. 96 St., Cleveland 2, Ohio.

Circle 564 on inquiry card.

Blowers, Fans. New Supplement of 11 data sheets for insertion in maker's catalogue lists centrifugal blowers and axial flow fans. Includes dimensions, performance, and ordering information.—Rotron Mfg. Co. Inc., Schoonmaker Lane, Woodstock, N. Y.

Circle 565 on inquiry card.

Valves

Solenoid Valves. New 4-page Circular VS-50 describes and illustrates maker's solenoid valves and automatic switches. Includes safety shut-offs, pilot lights, reverse-current relays, etc.—Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle 566 on inquiry card.

Control Valves. New 4-page bulletin illustrates and describes maker's line of control valves, solenoid valves, and self-operated regulating valves, for use with gas, air, and liquids. Includes types available.—A-P Controls Corp., 2450 N. 32 St., Milwaukee 45, Wis.

Circle 567 on inquiry card.

Valves. New 44-page illustrated Catalog 352 describes maker's globe and needle, check, relief, plug, and special valves. Includes applications, working pressures, dimensions, and ordering information.—Republic Mfg. Co., 1930 W. 77 St., Cleveland 2, Ohio.

Circle 568 on inquiry card.

Valves. New 8-page List Price Schedule 100-BB gives prices for freon and ammonia valves, driers, strainers, and accessories.—Henry Valve Co., 3215 North Ave., Melrose Park, Ill.

Circle 569 on inquiry card.

Valves. New 50-page Catalog A-205 illustrates and describes maker's

heavy-duty valve equipment for manual, electrical, or hydraulic operation. Includes gate, control, angle, butterfly, reversing, hot gas, check, for air and gas, and special application valves.—The Gas Machinery Co., 16100 Waterloo Road, Cleveland, Ohio.

Circle 570 on inquiry card.

Flow Control Valve. New bulletin illustrates and describes maker's "FC" flow control valve model designed to control the speed of the piston stroke in a cylinder. Various speeds obtainable by adjusting the valve screw. Includes dimensions and specifications. —Airmatic Valve, Inc., 7317 Associate Ave., Cleveland 9, Ohio.

Circle 571 on inquiry card.

Air Control Valve. New 4-page Bulletin "PB" illustrates and describes maker's solenoid pilot air control valve for handling air, vacuum, oil, water, and inert gases. Includes features, diagrams, and technical data.—Valvair Corp., 454 Morgan Ave., Akron 11, Ohio.

Circle 572 on inquiry card.

Oil Control Valves. New 6-page brochure illustrates and describes maker's "240-Y series" safety constant-level oil control valves that maintain even oil flow manually or automatically. Includes models available, specifications, dimensions, and typical installations.—A-P Controls Corp., 245 N. 32 St., Milwaukee 45, Wis.

Circle 573 on inquiry card.

Tubing, Hose, Fittings

Corrosion-proof Tubing. New 4-page Bulletin L-6506 illustrates and describes maker's "Dekoron" corrosion-proof tubing. Includes instrument tubing, "Metl-Cor" and "Poly-Cor" types, plus general properties of coating.—Samuel Moore & Co., Mantua, Ohio.

Circle 574 on inquiry card.

Tube Fittings. New 4-page Bulletin 4316B2 describes and illustrates maker's "Aluminum Triple-Lok" fittings for instrumentation and fluid handling for power plants, refineries, etc. Includes sizes available and applications. —The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle 575 on inquiry card.

Metal Hose. New 24-page Technical Data Book U-111 includes information on application, temperature ranges of types of metal and wire braided hose, dimensions, couplings, assemblies, etc. —Universal Metal Hose Co., 2133 S. Kedzie Ave., Chicago 23, Ill.

Circle 576 on inquiry card.

Insulated Meter Nuts, Unions. New 6-page Bulletin 522 describes and illustrates maker's insulating meter nuts and pipe unions to fit Emco, Sprague, Metric, and Tobey meters and which prevent galvanic corrosion. Includes price list.—Universal Controls Corp., 731 W. Davis St., Dallas, Texas.

Circle 577 on inquiry card.

Expansion Joints. New 4-page issue of "Cook Magnilastic Newsletter," is-

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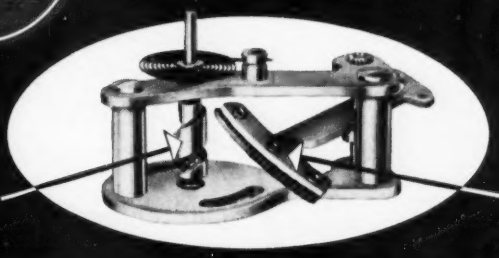
HELICOID GAGES



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For further information circle 185 on inquiry card.

NEW LITERATURE

sue 18, Vol. 2, features article on use of maker's bellows-type expansion joints in steam systems, etc.—Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill.

Circle 578 on inquiry card.

Motors

Fractional-hp. Motors. New 4-page Vol. 33, No. 2 issue of "The Bodine Motorgram" features article on use of maker's motors in "Teleplotter" automatic curve plotter. Also article on selection of proper brushes for motors.—Bodine Electric Co., 2250 W. Ohio St., Chicago 12, Ill.

Circle 579 on inquiry card.

Outdoor Motors. New 4-page Bulletin 05R7874 illustrates and describes maker's weather-protected motors for outdoor installations. Includes description illustrations, and use.—Allis Chalmers, Milwaukee 1, Wis.

Circle 580 on inquiry card.

Armature Testers. New 20-page Bulletin 110 illustrates and describes maker's "Armeters" for electrically testing armatures from "watch charms" to engine types.—P. E. Chapman Electrical Works, Inc., 1820 Chouteau Ave., St. Louis 3, Mo.

Circle 581 on inquiry card.

Rotor Tester. New 8-page Bulletin 115 illustrates and describes maker's new "Type IX" internal and external growler for testing squirrel-cage rotors for bad bars. Includes sizes, ranges and weights.—P. E. Chapman Electrical Works, Inc., 1820 Chouteau Ave., St. Louis 3, Mo.

Circle 582 on inquiry card.

Shop Equipment

Engraver Master. New 4-page Catalog 32T describes and illustrates 15 styles of letters and numerals in master type sets. Includes technical symbols.—Green Instrument Co., Putnam Ave., Cambridge 39, Mass.

Circle 583 on inquiry card.

Silver Brazing. New 10-page Bulletin 52-1-A is technical coverage of silver brazing preforms. Aims at solving complicated brazing problems and selection of proper preforms.—Lucas-Milhaupt Engineering Co., 5052 S. Lake Drive, Cudahy, Wis.

Circle 584 on inquiry card.

Ceramic Materials. New 4-page Bulletin 1051A illustrates and describes maker's "Stupalith," a group of low-expansivity ceramic materials providing resistance to extreme thermal shock.—Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.

Circle 585 on inquiry card.

Dip Soldering. New 2-page illustrated brochure presents new "Fusion TE-400 Electro-Tin" paste-type material with organic chemicals and tinning agents in suspension. Includes features and advantages for dip soldering and tinning of leads.—Fusion Engineering, 4504 Superior Ave., Cleveland 14, Ohio.

Circle 586 on inquiry card.

INSTRUMENT EVENTS Calendar

May 20-22
Spring meeting of SESA, Hotel Schroeder, Milwaukee, Wisconsin. For information write W. F. Hofmeister, Metallurgical Lab., Chain Belt Co., 4501 W. Greenfield Ave., Milwaukee, Wis.

May 20-22
First National Telemetering Conference, Edgewater Beach Hotel, Chicago, Ill., sponsored by Institute of Aeronautical Sciences, Institute of Radio Engineers, and Instrument Society of America.

May 24-28
Scientific Apparatus Makers Association, Annual Meeting, The Greenbrier, White Sulphur Springs, W. Va.

May 27-29
Annual Convention, American Society for Quality Control, Convention Hall Hotel, Philadelphia, Pa. For information write Alfred L. Davis, Ex. Sec., 70 E. 45 St., New York 17, N. Y.

June 10-20
Instrument Conference and Exhibit, Studieselskapet for Norsk Industri, Oslo, Norway. For information write H. Hennie Roed, Fra Studieselskapet, Munkedamsveien 53b, Oslo, Norway.

June 15-20, 22-25
University of Michigan courses in Automatic Control. For information write M. H. Nichols, Rm. 1523, E. Engineering Bldg., University of Michigan, Ann Arbor, Mich.

June 30-July 11
Second British Instrument Industries Exhibition, National Hall, Olympia, London, England. For information write E. L. Bols, Grand Buildings, Trafalgar Square, London, W.C.2, England.

July 20-31
Special summer program in Transistors, Massachusetts Institute of Technology. For information write Massachusetts Institute of Technology, Cambridge 39, Mass.

July 20-31
Boston College course in Industrial Spectrography. For information write James J. Devlin, S. J. Physics Dept., Boston College, Chestnut Hill 67, Boston, Mass.

July 27-31
Gordon Research Conference on Instrumentation, Colby Junior College, New London, N. H. For information write W. George Parks, Director, Chemistry Dept., University of Rhode Island, Kingston, R. I.

August 10-14
Gordon Research Conference on Analytical Chemistry, New Hampton School, New Hampton, N. H. For information write W. George Parks, Director, Chemistry Dept., University of Rhode Island, Kingston, R. I.

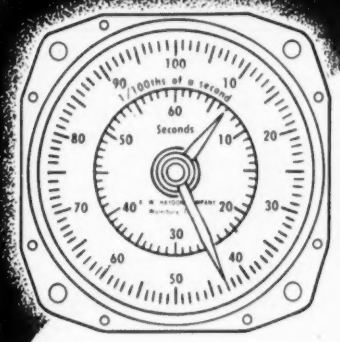
August 19-21
IRE Western Electronic Show and Convention, Municipal Auditorium, San Francisco, Calif.

August 24-26
Appalachian Gas Measurement Short Course, West Virginia University, Morgantown, W. Va. For information write G. W. Stuart, Equitable Gas Company, 3325 Hyperion St., Pittsburgh 14, Penna.

September 9-11
Conference on Nuclear Engineering, University of California. For information write R. A. Fayram, University of California, Berkeley, Calif.

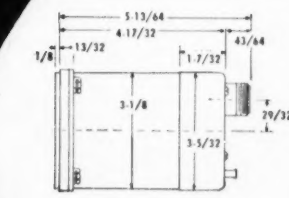
September 21-25
Eighth National Instrument Conference & Exhibit, Sherman Hotel, Chicago, Ill. For information write P. V. Jones, Mgr., Instrument Society of America, 1319 Allegheny Ave., Pittsburgh 33, Pa.

New A. W. HAYDON COMPANY



STOP CLOCK

High speed stop clock accrued seconds indicator with fluorescent dial and hands. Also available for other intervals.



SPECIAL FEATURES:
- Precision timing measuring hundredths of seconds to one minute.
- Automatic reset.
- Hermetically sealed.
- For operation on 50, 60, or 400 cycles A.C. or 20-30V D.C. 400 cycle unit has D.C. clutch.

This new, hermetically-sealed *Stop Clock* further enlarges the complete line of A. W. HAYDON COMPANY A.C. and D.C. Timers, time delay relays and timing motors. This accurate, panel-mounted timer totalizes hundredths of a second up to a minute. Hermetically-sealed, it weighs approximately 2 lbs. Comes with automatic reset.

WRITE FOR CATALOG

The A. W. HAYDON COMPANY
220 NORTH ELM STREET
WATERBURY 20, CONNECTICUT

For further information circle **186** on inquiry card.

Can you afford to be without corrosion-resistant thermometers?

Production errors caused by thermometer failures can be mighty costly.

The corrosion-resistant, pressure-tight construction of Rochester dial thermometers saves you this sort of expensive trouble. And it practically doubles the life of the thermometer under severe operating conditions.

An exclusive stainless steel welding process bonds case, stem and nut into a single corrosion-resistant unit.

RECALIBRATE ON THE JOB
Rochester dial thermometers are built to stay accurate under rough treatment. But if an unusually hard blow knocks the pointer out of adjustment, you can recalibrate it quickly and easily by turning a single screw.

You can order money-saving Rochester thermometers from one of our specialized instrument representatives, listed in Sweet's Catalog or the yellow pages of your telephone directory. Or write us direct for further details.

MILLIONS of Rochester dial thermometers are now delivering dependable service

Rochester Manufacturing Company, Inc.
85 Rockwood St., Rochester 10, N. Y.
DIAL THERMOMETERS GAUGES AMMETERS

For further information circle **187** on inquiry card.

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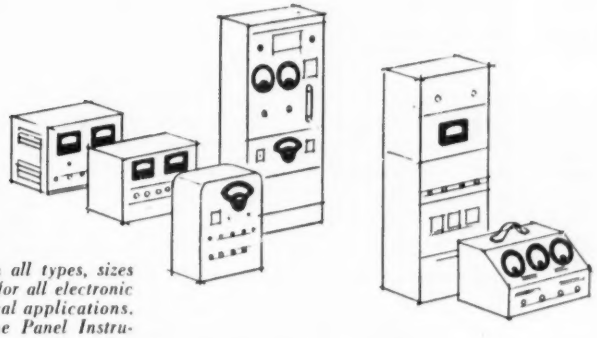
WESTON

PANEL INSTRUMENTS...

...outward evidence of the high quality built within fine electronic equipment



Available in all types, sizes and ranges for all electronic and electrical applications. Send for the Panel Instrument bulletin.

WESTON ELECTRICAL INSTRUMENT CORPORATION, 614 Frelinghuysen Avenue, Newark 5, N. J.

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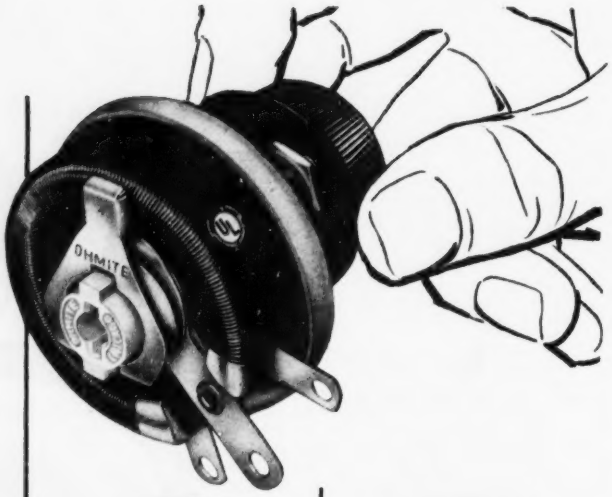
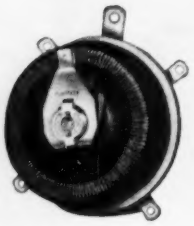
OHMITE® *RHEOSTATS*

WITH SPECIAL FEATURES . . .



BUSHINGS FOR SPECIAL PANEL THICKNESS

Extra-long bushings and shafts for mounting on panels up to 2" thick.



360° WINDING

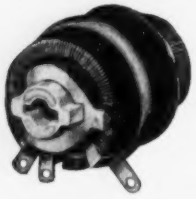
Available with continuous circular core and endless winding.

SCREW DRIVER SLOT SHAFT

Shaft ends slotted for occasional adjustments with a screw driver.

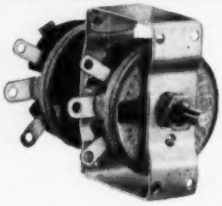
SEALED, ENCLOSED CAGES

Compact, corrosion-resistant metal cages, sealed by a double seam.



SNAP-ACTION OFF POSITION

Opens at high or low resistance position. Notch provides indexing.

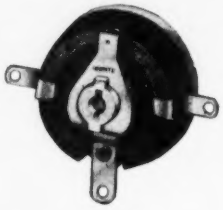


TANDEM ASSEMBLIES

Two or more rheostats in tandem for simultaneous operation.

TOGGLE SWITCH

Switch is operated with a positive snap by movement of the contact arm.



LESS THAN STANDARD ROTATION

Has winding space and angle of rotation less than standard.

• In addition to a complete line of standard rheostats, OHMITE manufactures a wide variety of rheostats with special features. All have the distinctive OHMITE design qualities: smoothly gliding metal-graphite brush; all-ceramic construction; insulated shaft and mounting; windings permanently locked in place by vitreous enamel. Specify OHMITE for your special-feature rheostats, and know you'll get the best!

Write on Company Letterhead for Catalog and Engineering Manual No. 40.

OHMITE MANUFACTURING COMPANY
4886 Flournoy Street, Chicago 44, Illinois

OHMITE

first IN WIRE-WOUND RHEOSTATS AND RESISTORS

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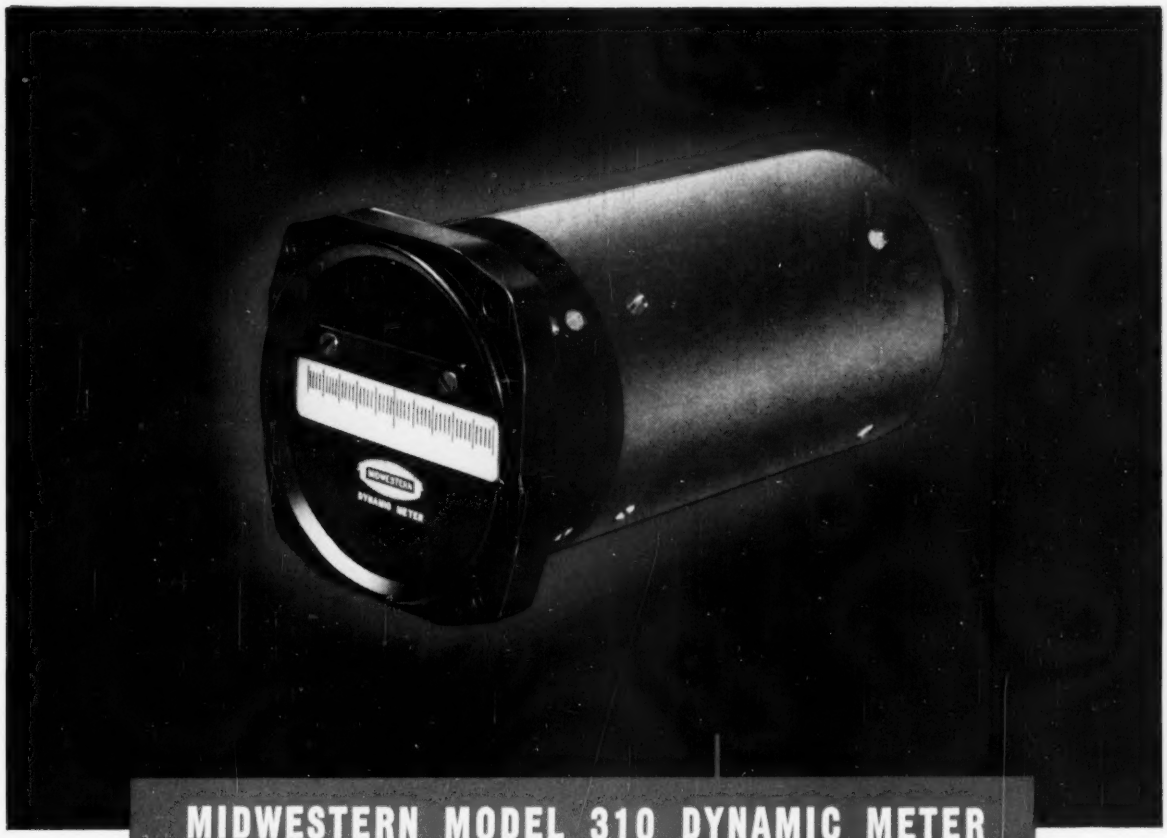

MIDWESTERN MODEL 310 DYNAMIC METER

The Midwestern Dynamic Meter is basically a miniature three-trace, lightbeam oscilloscope, designed for air-borne use to present flight test data for either visual or photographic observation. This instrument is precision-built and rugged; it is mounted on a standard AN 2¾ in. face instrument bezel.

Midwestern's extremely sensitive galvanometers produce appreciable meter deflections from conventional strain-gage signals without amplification. The light intensity of the edge-lighted Lucite screen may be varied (by external potentiometer) to produce the optimum photographic contrast between the signal spots and screen graduations. The instrument is virtually insensitive to the angular and lateral accelerations produced in piloted aircraft. This is due to the symmetrical design and excellent balance achieved in Midwestern galvanometers.

SPECIFICATIONS

ENGINEERING DATA

Optical arm of unit: 4.8 in.
Power Requirements: 24 volts at 1.5 amp
Connector: Winchester Electric Co. M9S
Weight: 2.3 lbs.

METER FEATURES

Standard AN instrument mounting
Galvanometers adjustable from front of instrument
Three-trace magnetic structure; Model 102 and 106 galvanometers available as required.
Static reference trace markers available
Full width viewing screen

BROCHURE CONTAINING COMPLETE DATA IS AVAILABLE UPON REQUEST

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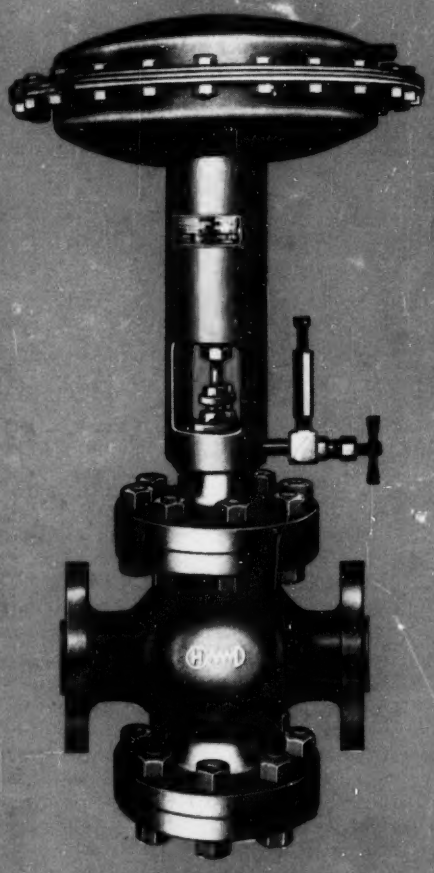

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